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EDITORIALS

CARDIFF, 1950

THIS year the members of the N.V.M.A. foregather in the Principality of Wales, and the host is the city of Cardiff. The provisional committee, whose is the duty to make the arrangements, has produced a programme which, judge it as you may, from the scientific angle or from that of those who favour the social and festive graces, bids fair to rival, and even excel, all previous congresses of the N.V.M.A.

The Welsh are a hospitable people, and that delightful trait always is at its best when they " play on the home ground." A previous congress at Llandudno still holds pleasant memories.

The choice of Cardiff as the venue could not be bettered, for here is a city renowned in history and steeped in tradition, yet one which has always looked forwards and moved with the times.

Up till one hundred years ago, Cardiff, although it was always an important local centre, had changed but little since the Roman conquerors of England established a fort on the site in the mistaken and vain hope that they might control the vigorous Welsh as they had done the more docile English. It was a monument to their stupidity. In more recent times, and especially with the onset of the industrial age, the city's development has been almost tumultuous towards the goal of becoming one of the finest jewels in our Empire. Taking advantage of every opportunity afforded for the expansion of industry, the City Fathers, and one must not forget the noble Crighton-Stuart family, have planned the development of the city, bearing in mind that man does not live by bread alone. Social, cultural and educational facilities have not been neglected, and to-day Cardiff, and, indeed, Wales, can be proud of their efforts and results in these directions.

They stand out as an example to others. With a delightful countryside

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within easy access for recreation during those hours when scientific matters can be laid aside, we are certain that Cardiff can, and will, provide all those requisites which will make this congress live in the memory as one of the best ever.

ANÆSTHESIA

THE first half of the twentieth century has been one of the most momentous periods in the history of mankind. It has been a period of great change, so great that conditions of life have been completely revolutionised. Science has been harnessed to the service of man, and as a result, except in those cases in which evil men have purposely prostituted science for ulterior motives, the world is a better place for man and his animals to live in. Progress has been made in every field of endeavour, and especially is this so as regards the so-called healing arts. Veterinary Science has not lagged behind, and the general advance in research has added so much to the store of knowledge that many of the difficulties and problems which beset our forebears have been resolved. By and large this is a true statement of the state of affairs in all branches of our work. In many cases Veterinary Science has outstripped the sister medical science, probably because veterinary surgeons can apply in the field the results of research with greater facility. In one sphere, however, i.e., anæsthetics, this is not the case, and this in spite of the fact that the preliminary research work entailed has of necessity to be conducted on animals long before it can be applied in the human operating theatre. Following the pioneer work of the late Sir Frederick Hobday on inhalant and local anæsthetics, no significant advances were recorded in this country until the introduction of the barbiturates in the early 1930's. Since that time the study of anæsthetics has forged ahead, not so much on account of the introduction of any new or revolutionary agents, but by improvements in methods of administration and a better understanding of the pharmacology of the drugs employed. Ether, the first of the volatile agents to be used for inhalation anæsthesia, still holds its own as the safest and most satisfactory anæsthetic to use on small animals on the majority of occasions. The development of new methods of administration, including endo-tracheal intubation, has widened the scope of this anæsthetic and made it safer even in those cases where its use would have been impossible previously.

A better understanding of the pharmacology of this anæsthetic and of alternative agents such as chloroform enable us to use them with more discretion, for we know with greater precision the indications and contra-indications for any particular purpose or set of circumstances. Premedication by the use of relaxant drugs is a most valuable adjunct to anæsthesia. The early experimental work on these, and also on the use of curare and myanesin, was carried out on animals, mainly rabbits and dogs, yet we find in this instance that as regards application in the field the veterinary surgeon lagged about a decade behind his medical friends.

On the whole, most of the advances in modern anæsthesia depend upon

new techniques of administration and require no elaborate special apparatus or skill, and any competent veterinary surgeon could apply them. Good anæsthesia is essential in any surgical work; bad anæsthesia can vitiate the work of the most brilliant surgeon. Making use of modern techniques, i.e., endotracheal intubation and positive pressure apparatus, the fields available for surgical intervention are opened wide. A veterinary surgeon can operate on sites which were previously inaccessible, and intrathoracic surgery, for instance, can become as common and as safe as is our work on the abdomen.

In this issue we publish an article on anæsthesia in the dog. The scope of the article is wide. Time-honoured agents such as ether, chloroform and the barbiturates all come under review, as do some of the lesser-known agents, such as trilene and nitrous oxide. A large section of the article deals with techniques employed in this country and America during recent years. The problems of premedication, and of pre- and post-operative care, are given full regard. We commend the article particularly to all those veterinary surgeons who practise canine surgery.

National Veterinary Medical Association

ANNUAL CONGRESS, CARDIFF, 1950

PROGRAMME

(All Papers will be presented and discussed at the Cardiff Technical College.)

SUNDAY, SEPTEMBER 3

7.00 p.m. "At Home" in the Whitehall Rooms, Park Hotel, Cardiff.

MONDAY, SEPTEMBER 4

10.30 a.m. Civic welcome by the Lord Mayor of Cardiff (Alderman George Williams, C.B.E., J.P.).

11.00 a.m. Official opening of the Exhibition of Surgical Instruments, Drugs, etc., by the President, N.V.M.A., at the Cardiff Technical College.

11.00 a.m. Ladies' pleasure trip to Porthcawl.

11.15 a.m. Paper: "Factors Influencing Herd Fertility in Cattle." By S. L. Hignett, B.Sc., M.R.C.V.S. (Frant). Openers: D. W. Deas, M.R.C.V.S. (Lasswade), J. Smith, M.R.C.V.S. (Carmarthen), H. W. Steele-Bodger, M.R.C.V.S. (Tamworth). Chairman: T. H. Jones, M.R.C.V.S. (Llandilo). Recording Sec.: D. R. Allen, M.R.C.V.S. (Cardiff).

2.15 p.m. Demonstrations at Whitchurch Mental Hospital Farm. "Soundness in both the Heavy and Light Horse." By Brig. E. S. W. Peatt, O.B.E., F.R.C.V.S. (Ashford). "General Anæsthesia in Small Animals, and a Method of Positive Pressure Ventilation of the Lungs." By G. C. Knight, F.R.C.V.S. (Royal Veterinary College) and C. R. Wood, M.R.C.V.S., D.V.S.M.(Vict.), Wimbledon. "Epidural and Regional Anæsthesia in Small Animals." By Dr. J. S. A. Spreull, M.R.C.V.S. (Dundee). "General Anæsthesia in Cattle by the use of Anavenol with Kemithal." By W. T. Harrow, M.R.C.V.S. (Wilmslow).

3.00 p.m. Film show of medical films at the Technical College. "Operative Shock." "The Cerebral Cortex of the Monkey." "Control of Infection in Surgical Dressings" (Parts 2 and 3).

7.30 p.m. for 8 p.m. Civic Reception, at the Assembly Room, City Hall, Cardiff.

TUESDAY, SEPTEMBER 5

9.30 a.m. Paper: "Clinical Diagnosis of Diseases of the Abdomen of the Dog and Cat." By J. S. J. Lauder, M.R.C.V.S. (Hale Barns).

10.30 a.m. Ladies' pleasure trip to Wye Valley. (Leave Cardiff Technical College 10.30 a.m.)

11.00 a.m. Paper: "Some Pig Diseases." By Dr. H. G. Lamont, O.B.E., M.R.C.V.S., D. Luke, B.Sc, M.R.C.V.S., W. A. M. Gordon, M.R.C.V.S. (Belfast). Openers: P. L. Shanks, B.Sc., M.R.C.V.S. (Leeds), J. F. Timoney, M.R.C.V.S. (Dublin). Chairman: J. Campbell-Hill, M.R.C.V.S. (Llanelly). Recording Sec.: D. G. Llewellyn, M.R.C.V.S. (Cardiff).

3.00 p.m. Film show at the Technical College. (Repeat of Monday's showing.)

5.00 p.m. N.V.M.A. Council Meeting in the Council Chamber, City Hall, Cardiff.

7.30 p.m. for 8 p.m. President's Reception at the Park Hotel, Cardiff.

WEDNESDAY, SEPTEMBER 6

10.30 a.m. Paper: "Deficiency Diseases, particularly Acetonæmia in Cattle." By Professor Birger Carlstrom (Stockholm).

2.30 p.m. Congress photograph on the steps of the Welsh National Museum, Cathays Park, Cardiff.

3.00 p.m. N.V.M.A. Annual General Meeting at the Cardiff Technical College.

7.30 p.m. for 8 p.m. Annual Banquet in Whitehall Rooms, Park Hotel, Cardiff.

THURSDAY, SEPTEMBER 7

10.00 a.m. Paper: "Symposium on Diseases of Sheep." By Dr. S. Jamieson, M.R.C.V.S., D.V.S.M. (Aberdeen), L. E. Hughes, M.R.C.V.S., Dip. Bact. (Aberystwyth), W. T. Rowlands, M.R.C.V.S., D.V.S.M. (Bangor), and J. T. Stamp, B.Sc., M.R.C.V.S. (Edinburgh). Openers: D. E. Davies, M.R.C.V.S. (Llanybyther), D. R. Allen, M.R.C.V.S. (Cardiff). Chairman: Dr. R. F. Montgomerie, B.Sc., F.R.C.V.S. (Senr. Vice-President, N.V.M.A.). Recording Sec.: D. K. Bryson, M.R.C.V.S. (Carmarthen).

11.45 a.m. Sectional Meetings.

(1) Association of Veterinary Teachers and Research Workers.

(2) Society of Practising Veterinary Surgeons.

Afternoon. (*a*) Pleasure trip to Barry Island.

Free admission to Collins' Fun Fair.

Bowls competition at invitation of Barry Athletic Club. (Organiser: R. W. Hall, M.R.C.V.S., Barry.)

Tea at the Merrie Friars Café, Barry, at the invitation of the President, South Wales Division, R. W. Hall, M.R.C.V.S.

Leave Technical College 1.30 p.m. Tea, 5 p.m. Arrive Cardiff about 6 p.m.

(*b*) Golf competition at the Penylan Golf Club. (Organiser: C. J. Pugh, M.R.C.V.S.)

8.30 p.m. Ladies' Guild Dance at the Whitehall Rooms, Park Hotel.

FRIDAY, SEPTEMBER 8

10.00 a.m. Paper: "Diseases of the Stomach of the Adult Ruminant." By H. Begg, M.R.C.V.S. (Strathaven). Openers: A. T. Morgan, M.R.C.V.S., D.V.S.M. (Carmarthen), D. G. E. Davies, M.R.C.V.S. (Llandyssul). Chairman: R. W. Hall, M.R.C.V.S. (Barry). Recording Sec.: R. H. Packer, M.R.C.V.S. (Barry).

11.30 a.m. Paper: "Strain 19 Vaccine and the Control of Brucellosis." By J. R. Lawson, M.R.C.V.S. (Weybridge). Openers: A. J. Wright, M.R.C.V.S. (Macclesfield), L. G. Anderson, D.V.M., M.R.C.V.S. (Aylesbury). Chairman: G. N. Gould, M.R.C.V.S. (Hon. Secretary, N.V.M.A.). Recording Sec.: R. C. Locke, M.R.C.V.S., D.V.S.M.(Vict.) (Newport).

2.30 p.m. Closing meeting of the Congress at the Cardiff Technical College.

4.00 p.m. Council meeting of the N.V.M.A. at the Cardiff Technical College.

SOCIAL EVENTS DURING N.V.M.A. CONGRESS

1. SOUTH WALES DIVISION "AT HOME," SUNDAY, SEPTEMBER 3.

Guests will be received by the President of the South Wales Division and Mrs. Hall, in the Whitehall Rooms, Park Hotel, beginning at 7 p.m. Buffet refreshments. Lounge suits.

2. LADIES' PLEASURE TRIP TO PORTHCAWL, MONDAY, SEPTEMBER 4.

By coach, leaving Cardiff Technical College at 11 a.m., lunch at the Esplanade Hotel, Porthcawl. The party will get back to Cardiff at about 4.30 p.m. Tickets: 10s. 6d. each (including lunch).

3. CIVIC RECEPTION, MONDAY, SEPTEMBER 4.

Guests will be received by the Lord Mayor and Lady Mayoress of Cardiff at the Assembly Rooms, City Hall, at 7.30 p.m. There will be buffet refreshments and dancing. Evening dress. (The Lord Mayor asks that members attending this function should notify his office on postcards which will be supplied by the N.V.M.A., giving the names of each and every ticket-holder for this function.)

4. Ladies' Pleasure Trip to the Wye Valley, Tuesday, September 5.

By coach from Cardiff Technical College at 10.30 a.m., via Newport, Chepstow and Tintern, lunch at the Beaufort Hotel, Tintern, and returning via Monmouth, to arrive in Cardiff at about 4.30 p.m. Tickets: 13s. each (including lunch).

5. President's Reception and Dance on Tuesday, September 5.

The President and Mrs. Bruford will receive guests at the Park Hotel, Cardiff, at 7.30 p.m. Buffet refreshments. Evening dress. Each member may have two free tickets and a maximum of two additional tickets at 15s. each.

6. Congress Photograph, Wednesday, September 6.

This will be taken on the steps of the Welsh National Museum, Cathays Park, at 2.30 p.m.

7. Annual Banquet, Wednesday, September 6.

This will be held in the Whitehall Rooms, Park Hotel, 7.30 for 8 p.m. Evening dress. Tickets: 15s. each.

8. Pleasure Trip to Barry Island, Thursday, September 7.

In connection with this pleasure trip, the Barry Athletic Club invite members to take part in a bowls competition, and those wishing to do so should send their names to Mr. R. W. Hall, Tynewydd Road, Barry, before the opening day of Congress if possible. The coach will leave the Cardiff Technical College at 1.30 p.m. After the bowls competition tea will be served at 5 p.m. at the Merrie Friars Café, Barry, at the kind invitation of the President of the South Wales Division (Mr. R. W. Hall), and all will have free access to Pat Collins' Pleasure Park on presentation of the Congress Badge. The party will aim to be back in Cardiff at 6 p.m. Tickets: 3s. each (unless own car preferred—see Application Form).

A Golf Competition, organised by Mr. C. J. Pugh, Stow Hill, Newport, will be held at the Penylan Golf Club, also on September 7. Intending competitors should let Mr. Pugh have their names as soon as possible after arrival in Cardiff.

9. Ladies' Guild Dance, Thursday, September 7.

This will be held, in aid of veterinary benevolence, in the Whitehall Rooms, Park Hotel, at 8.30 p.m. Running buffet. Evening dress. Tickets: 1 guinea each.

GENERAL ARTICLES

INVESTIGATION AND TRIALS WITH INSULATED CONTAINERS FOR THE TRANSPORT OF SEMEN

By D. NORTH-LEWIS,

Central Artificial Insemination Station, Department of Veterinary Services, Kabete, Kenya.

THE main function of the Central Artificial Insemination Station at Kabete, Kenya Colony, is the distribution of bovine semen to various parts of the Colony. A small proportion of semen is consigned by air, but the bulk is despatched by rail.

Semen is distributed by train up to 280 miles, with an average distance of approximately 125 miles. The train service is comparatively slow and the longest journeys normally take nearly twenty-four hours. Kenya railway stations are generally staffed by Asian and African stationmasters with African porters. As many of the latter are illiterate they can have little respect for packages marked, " Glass, with Care," " Fragile," etc., and special packing is needed to avoid excessive breakages. From the railhead to the ultimate destination, be it an artificial insemination sub-station or farm, the transport is by a variety of vehicles, from ox-wagons to saloon cars, all of which have to travel over very rough tracks.

It must be appreciated, therefore, that to ensure the regular arrival of high-grade semen in good condition at its final destination, one of the main problems facing the Kenya Artificial Insemination Service was to find a suitable container in which to transport it. The aim was to evolve something which would withstand rough handling, maintain a low temperature for at least twenty-four hours, and at the same time be reasonably light to come within the minimum freight charges.

The ordinary household thermos flask, packed with ice, appeared, at first sight, to provide the answer, but the problem of safe transport still remained.

1. Household Thermos Flasks Packed in Cardboard Boxes

The first trials were with thermos flasks packed in sawdust in cardboard boxes, 24 in. x 12 in. x 6 in. These proved most disappointing, and it soon became obvious, with breakages amounting to some 20 per cent on thermos journeys, that another system of packing had to be sought.

2. R.A.F. Metal Vacuum Containers

It was then decided to experiment with R.A.F. cylindrical vacuum containers, the dimensions of which were 13 in. x 7 in. These comprised an inner and outer container with a $\frac{1}{2}$ in. cork insulation between the two metal walls. The opening at the top was provided with a hinged metal lid which closed on to a thick rubber washer and was held in position by two clips on either side. They were easily carried by a light chain attached to the lid fasteners. The con-

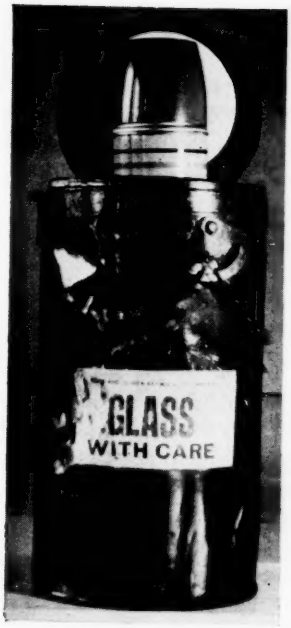
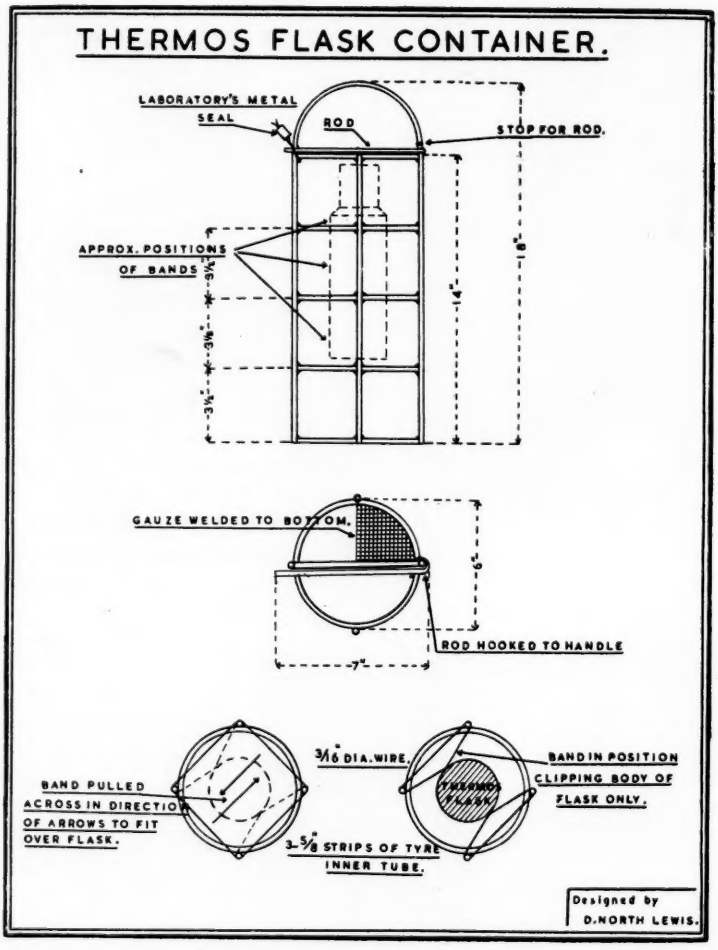


FIG. 1.

FIG. 2.

FIG. 3.

(*Article by D. North-Lewis, page* 318.)



(*Article by D. North-Lewis, page* 318.)

tainers, which cost 20s. each, with a fully-charged thermos flask packed in sawdust in the centre, weighed 13 lb. (See Photograph No. 1.)

This method of packing semen for transport was a decided improvement on the cardboard boxes, but, over a trial period of about six months, breakages of the enclosed thermos flasks continued to be high, and in one month reached a figure of 14 per cent of a total of 168 thermos journeys. It was obvious from the outward appearance that the containers had been subjected to severe handling, and the thermos flasks transported therein could not possibly withstand such harsh treatment.

3. Wide-mouth Thermos Jar with Aerated Rubber Packing

The majority of breakages of thermos flasks appear to occur at the neck, where the glass is suspended to the outer metal container. With a view to distributing the weight over a larger carrying surface on the glass component, Messrs. Holborn Instrument Co. were asked to modify a standard wide-mouth thermos jar by packing the space between the glass and the metal with aerated rubber. Such a flask, placed in a felt-padded wooden box, proved highly satisfactory, and remained unbroken after continuous use over a long period; however, it was too costly to introduce as a standard carrier.

4. Container Insulated by Baked-spun Rubber

Messrs. Arnold & Son evolved a metal container with a diameter of 14 in. and a depth of 15 in., weighing 15 lb., with a $\frac{3}{4}$ in. lining of baked-spun rubber, which provided insulation for an ice box $5\frac{3}{4}$ in. in diameter by $6\frac{1}{2}$ in. deep, situated in its centre. The whole container was first cooled and the semen, in test tubes, was placed into six metal cups, $1\frac{1}{4}$ in. in diameter and $3\frac{1}{4}$ in. deep; these cups were suspended from a 1 in. thick rubber lid which fitted into the top of the ice box. The whole container was sealed by a $3\frac{3}{4}$ in. deep baked-spun rubber lid clamped down by three metal clamps. (See Photograph No. 2.)

This provided an ideal method for the safe transport of large quantities of semen to the sub-stations; but the cost of the container is high and it is not an economical way of distributing small quantities of semen to farmers. It should be mentioned that approximately 120 carriers or containers are required to maintain the regular service provided at Kabete.

5. "Parrot Cage" Carrier

It became apparent that an open container displaying its contents (i.e., a thermos flask) might be an advantage, since the people handling it, and noting the fragile nature of the consignment, would automatically exercise more care, and with this in mind the carrier illustrated here was designed and brought into general use. (See Photograph No. 3 and diagram.)

This is a circular carrier of a diameter of approximately 7 in., made from $\frac{3}{16}$ in. thick wire. It has a maximum height of 18 in. from the base to the rod across the top of the carrier. This rod, to which the handle is hooked, is hinged, and after introducing the flask it is sealed with a lead seal to prevent unauthor-

ised tampering. Wire gauze is welded across the base of the container, and at 3½ in. intervals wire rings are welded to the main frame as a protection for the flask. The carriers are made by a local engineering firm and cost 12s. each.

The flask is an ordinary household thermos flask, obtainable locally in almost any hardware store and retailed at Sh 7/50. The flask is suspended in the wire frame by three pairs of ⅜ in. strips of rubber tubing made by cutting the inner tube of a motor car tyre.

To place the rubber bands in position on the thermos flask a section of rubber is looped over the thumbs; the thumbs, held apart, are then moved forward, carrying the rubber band from the outside of the uprights of the container in the direction of, and beyond, the top of the flask. The thumbs are then brought together, and the adjacent section of rubber passed, one thumb to the other, thus crossing them, the loop so formed being passed over the top of the flask and then lowered to a position parallel to the base. To centralise the flask, a second band is similarly placed in a position from the upright immediately opposite. The perpendicular position of the flask is maintained by similar pairs of rubber bands placed at its centre and base.

Of all the methods of packing and transporting semen described in this paper, the wire cage has proved the most satisfactory. Breakages have been reduced to an insignificant fraction and the cost of the "Parrot Cage" is reasonable.

Dispensing and Despatching of Semen

When despatching semen the following method of packing is used: Cotton waste to a depth of 2 in. is placed in the bottom of the thermos flask and the tube, or tubes, of semen are wrapped in cotton-wool; these are introduced and kept central by chipped ice, packed within about 1 in. above the tubes, corked and sealed with paraffin wax. Certificates giving details of the semen contents are placed in the base of the cup before screwing the lid into position.

The flasks in use at Kabete take four tubes, each holding up to 10 c.cs. of semen, and the weight of the whole container and flask, when fully charged, is approximately 3 lb.

To minimise breakage, clients are requested to remove empty semen tubes and any remaining particles of ice, before returning flasks. Breakages of flasks over a twelve-month period average less than five per cent. An average of approximately 400 flasks make double journeys each month. The quality of the semen is not affected and the conception rate remains good following the use of semen packed and transported by the method described.

Summary

In Kenya, where semen has to be distributed in relatively small amounts, using rail and road vehicle transport, a cheap method by which semen can be transported at low temperatures is an essential. A "Parrot Cage" carrier for thermos flasks has been evolved which, because the contents are patent and

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obvious to illiterate persons who have to handle the packages, has reduced the rate at which thermos flasks are broken to an insignificant figure. Such a carrier can be made locally from thick wire and a disused inner motor rubber tube, at a very low cost.

A wide-mouth thermos jar with aerated rubber packing between the glass and metal, made up by Messrs. Holborn Instrument Co., and a metal container insulated by baked-spun rubber, evolved by Messrs. Arnold & Sons, have been discussed. Although giving good results, these were too costly for large-scale use.

SOME CLINICAL OBSERVATIONS ON LEPTOSPIROSIS IN SUBURBAN DOGS*

By JOAN O. JOSHUA, M.R.C.V.S.,
Finchley.

Historical

Case records of human jaundice which are now accepted as being the earliest reports of leptospiral infection appeared during the last quarter of the nineteenth century, but the causal organism was not isolated until 1914 when Inada *et al.* demonstrated a spirochæte, which they named *Spirochæta icterohæmorrhagiæ,* as being the cause of Weil's disease. The generic name of *Leptospira* was shortly afterwards adopted.

In 1925, Okell, Dalling and Pugh described a disease occurring sporadically in older dogs and enzootically in young stock which they called " Yellows " and showed to be due to infection with *L. ictèrohæmorrhagiæ.*

In 1933 a species of *Leptospira* was isolated from dog's urine by Klarenbeek and Schüffner and was named *L. canicola;* in contradistinction to the majority of species *L. canicola* has not been isloated fro many other host than the dog and man, the former being apparently the natural reservoir.

During the last 25 years many strains of leptospires have been identified, serological methods being used for their differentiation and classification. Broadly speaking the greatest number of varieties have been identified in the Netherlands East Indies and Europe; in the latter case the work of Borg-Petersen in Denmark in the classification of strains is outstanding.

In Great Britain the only species so far identified are *L. icterohæmorrhagiæ* and *L. canicola.* With the exception of rats and one investigation of a colony of wood mice, no survey of the rodent population of this country has been carried out for the purpose of recovering strains of leptospires. In the case of the wood mice a strain was isolated but was not cultivated or identified. (Elton *et al.*). Since preparing the preliminary draft the serum of one cat has shown agglutinins in low titre to *L. grippotyphosa.*

* This paper is reproduced by courtesy of the Royal College of Veterinary Surgeons, by whom it was accepted for the award of the Fellowship Diploma to the author.

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So far as the domestic animal population of Great Britain is concerned the first recorded leptospiral infection is, as previously mentioned, that reported by Okell, Dalling and Pugh. Since 1925 leptospiral jaundice of dogs has received occasional attention in the literature.

In 1946 Stuart recorded the results of a series of agglutination tests carried out on street dogs in Glasgow, which revealed 52 per cent reactors to *L. canicola*. No case of clinical disease was described. In 1947 Joshua and Freak recorded the use of penicillin in active cases of *L. canicola* infection and since that time canine leptospirosis has received attention from Mills (1948), Stuart and McIntyre (1949) and Joshua and Broom (1949).

So far as other animal species in this country are concerned two cases of *L. icterohæmorrhagiæ* infection have been reported in calves. A series of cat sera has been examined and shows approximately 10 per cent reactors to *L. icterohæmorrhagiæ* in low titre only; several cases of jaundice in cats have been fully investigated, but leptospires have not been incriminated to date. One cat in the series has agglutinated *L. grippotyphosa* in low titre. The significance of this finding is problematical.

Introduction

This paper sets out to describe the clinical manifestations of leptospiral infection in dogs as seen by the author in an average London suburban area. The disease caused by both *L. canicola* and *L. icterohæmorrhagiæ* is described. In addition to a description of the clinical symptoms, consideration is given to possible routes of infection (i.e., portals of entry of the organism), transmission of infection, treatment and the relationship of the disease to canine nephritis.

A survey of an unselected series of dogs for the presence of agglutinins should properly be the province of an institution, such as a large out-patients' clinic, where a large number of dogs is seen annually and statistics are available for total numbers, sex, etc., but within the scope of a private practice a series of bloods has been examined and the results of these agglutination tests are discussed from the point of view of age, sex and breed.

Diagnosis is viewed from the standpoint of the average veterinary surgeon engaged in small animal practice and with the usual indirect contact with a laboratory service. In these circumstances diagnosis has been based on clinical examination in conjunction with a common-sense interpretation of the agglutination test. In view of the universally accepted specificity of the agglutination test it has not been considered necessary to demonstrate the organism to establish diagnosis.

Case records are appended to illustrate the various types of disease described.

L. Canicola Infection

In general, primary infection with *L. canicola* gives rise to a renal train of symptoms. In the author's experience the sub-acute form of the disease has been most common, and in no case has a bacteriæmic phase, as described by Stuart and McIntyre been recognised, even the most acute cases proceeding direct to

renal failure. It seems probable that the clinical syndrome may vary in different parts of the country due either to a variable susceptibility of the canine population connected with the length of time infection has been present in a given area, or to a difference in virulence of the invading strain of leptospire in a particular area. Support is given to this supposition by a description of the disease given by Joan Milnes of Huddersfield (private communication) who described a type of disease intermediate between that described in Scotland and that seen in the London area; this clinician describes a transient myositis with temperature rise and malaise as the initial phase of the disease, this differing somewhat from the bacteriæmic phase of Stuart and McIntyre, and yet being more acute than the average case seen in the London area, in which myositis, if it occurs at all, is slight only, exceedingly transient and not usually accompanied by temperature rise and malaise.

The following is a description of the disease as observed by the author.

1. *Acute.* Illness is ushered in by profuse and frequent vomiting accompanied by severe depression which passes in a matter of 12-48 hours into a state of prostration. Bowel action is usually in abeyance, but occasionally there is a passage of slightly blood-stained fæces in the early stage. Excessive thirst is usually evinced, but fluids are not retained and dehydration of the tissues is rapid; this phase may be succeeded by the refusal of fluids. If these cases are examined during the first 24 hours of illness a slight temperature rise may be noted, usually not exceeding 103.5°F.; depending on the severity of the case this normally falls within 24-72 hours to a sub-normal or even collapse temperature. There is relative or complete anuria. Ulceration and necrosis of the buccal mucosa and tongue occur within 24-72 hours of the onset of symptoms, and are rapidly progressive. Death occurs in 36-96 hours from acute uræmia and is often preceded by the vomiting and passage per rectum of large quantities of foul-smelling blood-stained fluid. This clinical picture resembles in some respects the disease described by some workers as Stuttgart disease or Canine Typhus.

2. *Sub-Acute.* This group of cases is probably rarely seen at the time of invasion, and is usually presented at a stage when mild nephritic symptoms are evident. In such cases it is often possible to elicit a history of transient muscular pain some 2-6 weeks before the development of other symptoms; this phase is not accompanied by systemic disturbance and is usually dismissed by the owner as " a touch of rheumatism."

Symptoms at the time of examination are vomiting, increased thirst, a variable degree of depression. Appetite may be affected and varies from complete refusal of food to an apparently normal healthy appetite. Similarly loss of flesh may or may not be noted. A " tucked-up " posture is common.

Examination.—Temperature is rarely markedly affected but may be elevated in the early stages in an occasional case; it is more usually slightly sub-normal (100-100.5°F.). Pulse may be full and bounding or weak and thready; in dogs of slim build marked aortic pulsation may often be detected on abdominal palpation; the author's tentative suggestion as to the reason for this latter sign

is the increased blood supply to the infected kidneys and consequent alteration in aortic pressure. Episcleral injection has been described by Winsser as a common finding; the author has seen it on a number of occasions but would not regard it as a reliable feature and in any case would prefer to describe it as an engorgement of the episcleral vessels as the picture is quite different from the episcleral injection or congestion which is a feature of " hard pad " disease. The conjunctiva is otherwise normal.

The buccal mucosa is almost invariably affected, and changes in it and the tongue can be detected by careful examination in nearly every case. The buccal mucosa is drier than normal and may be pallid; ulceration adjacent to the canine and carnassial teeth of the type associated with nephritis occurs later in the disease; the dorsum of the tongue is dry and in the majority of cases is changed in colour, the usual healthy pink tinge being lost and a colour varying from a faint brick red to a definite brown film replaces it. This brown film on the surface of the tongue is quite distinct from the deposition of brown slime on the tongue and teeth in so-called " brown-mouth disease." This may progress to a dry necrosis of the tongue tip. The odour from the mouth varies; it is occasionally normal but commonly a faint uræmic smell is detectable, and in some cases a characteristic but indefinable odour is present which the author finds difficult to describe other than as reminiscent of a ketosis.

Abdominal palpation elicits pain or tenderness in the renal area and frequently a much enlarged left kidney may be palpated; the author has palpated a kidney the size of an average orange in a Scottish Terrier, and one the size of a Jaffa orange in an Alsatian.

3. *Mild.* This category includes a number of nebulous types of malaise, some so slight that they are virtually disregarded. Vomiting and depression are common and no other symptoms or signs may develop; this type of case includes those variously diagnosed as indigestion, gastritis and liver attacks. Failure of such a case to respond to symptomatic treatment should arouse suspicion of leptospirosis even in the absence of any evidence of renal involvement.

Also in this category may be included dogs which exhibit only increased thirst and corresponding polyuria; in the author's view all cases displaying these symptoms without obvious cause should be regarded as suspect.

4. *Atypical Cases.* Certain cases have been seen which have been quite atypical. One such case showed heart symptoms only, the dog (a young adult) having frequent heart attacks and tiring easily, but being otherwise normal in all respects. On auscultation the only departure from normal appeared to be a very weak first heart sound. In the sixth week of illness there was some increase in thirst and a very slight dryness of the mouth which aroused suspicion. This train of symptoms was probably due to endocarditis.

Another abnormal type of case is that in which considerable and widespread tissue damage occurs, probably associated with secondary bacterial infection. One such case showed gross liver enlargement with jaundice, peritonitis, pericarditis, pleurisy and pneumonia.

Cough and tonsilitis are symptoms occasionally noted but not considered typical.

One case was seen in which temperature rise, muscular pain, arthritis, cellulitis and œdema of the hocks were predominant symptoms.

5. *Sub-Clinical.* In the author's view there is little doubt that infection with *L. canicola* can occur without causing clinical symptoms at any stage. The series of blood examinations includes a number from dogs of over middle life whose history has been known to the author from early puppyhood and which have never at any time had an illness which could conceivably be due to leptospires; some have been destroyed while in normal health for reasons of temperament, etc., others for diseases quite unconnected with leptospirosis, such as neoplasia or pyometra, yet these dogs have shown agglutinins to *L. canicola,* some to as high a titre as 1 : 300, which in the author's submission probably indicates residual infection in the kidneys.

The above types of case are described as being typical of primary *L. canicola* infection. Cases of recurrent nephritis associated with previous *L. canicola* infection will be considered when the relationship of leptospirosis to canine nephritis is discussed; such cases, many of which are undoubtedly due to previous leptospiral infection and some of which may continue to harbour the organism in the kidneys, are well recognised by clinicians, but the author prefers to exclude them from a discussion of primary leptospirosis.

Case Protocols

The following case records have been selected to illustrate the various types of leptospiral infection described.

Acute

3 yr. Scottish Terrier, m.

History.—Illness of 3½ days' duration . Acute vomiting, increased thirst, great dullness. Defecation in abeyance. Passing small quantities of urine only. This dog had been immersed in a local brook one week previously.

Examination.—Temperature 102.5°F. Mucous membranes normal. The dog was dull to the point of prostration. The buccal mucosa was dry and there was evidence of threatening necrosis of the tongue tip.

Past experience of cases of this type is sufficient to forecast that without specific treatment this dog would have progressed to acute uræmia and death, following a syndrome resembling so-called Stuttgart disease.

Penicillintherapy was instituted and the usual spectacular response occurred, followed by recovery in 4-5 days.

In this case a blood sample was taken on the first occasion the dog was presented, i.e., on the fourth day of illness, and was positive to *L. canicola* at 1 : 30, with a trace of agglutination at 1 : 100; there was para-agglutination to *L. icterohæmorrhagicæ* at 1 :30 only. Owing to subsequent illness of the owner

it was not possible to take a second blood later in the case, nor to carry out any further investigations.

In the acute case of this type in which penicillin therapy is instituted early the characteristic rise in titre may not occur. The dramatic response of such a case to penicillin is, in the author's view, confirmatory evidence that the cause of the illness was *L. canicola* infection.

Sub-Acute

1 yr. Scottish Terrier, m.

History.—Definite illness of one week with thirst, dullness and a tucked-up appearance. Further enquiry elicited the information that the owners did not consider the dog had been "quite right" for a period of six weeks +.

Examination.—Temperature 103.8°F. Condition very poor, hidebound. Tucked up in loin. Buccal mucosa slightly dry. Left kidney enlarged and painful.

Blood.—Positive to *L. canicola* 1 : 10,000.

„ „ *L. ictero.* 1 : 100.

Urine.—Specific gravity: Insufficient. Reaction acid. Albumen +, Bile pigments and sugar negative. Later urine samples gave S.G. 1,026.

Penicillin therapy was instituted and the general response was good but slight albuminuria persisted. A slight uræmic odour could still be detected when the dog was examined three weeks later and it was considered that residual kidney damage and possibly persisting colonies of leptospires in the kidneys were present.

At this stage the dog was given 1 gramme streptomycin divided equally over a 3-day course. Further clinical improvement occurred and a urine sample examined two months subsequently was negative for albumen and showed a rise in S.G. to 1,042. The uræmic odour had disappeared one week after the streptomycin treatment and the dog was considered to be clinically normal.

Mild

2 yr. mongrel, Terrier type, m.

History.—Vomiting and inappetence for 2 days.

Examination.—Temperature 101.4°F. Depressed appearance, tucked up, otherwise normal.

There was considered to be insufficient evidence to justify more than the slightest suspicion of leptospirosis at this stage. Two days later there was no improvement in response to symptomatic treatment and very slight ulceration of the buccal mucosa was detected.

Penicillin therapy was instituted and an uneventful recovery followed.

Blood—($2\frac{1}{2}$ weeks after onset of symptoms).

L. canicola 1 : 100. *L. ictero.* Neg.

Atypical Cases

A. A case of uncertain duration involving widespread tissue damage and probable secondary infection.

Subject.—Scottish Terrier: 5-6 years: male.

The history of this case is probably inaccurate and incomplete owing to the owner being an invalid and unable to give any detailed observations of the dog's condition; for example, the history was said to be of only 48 hours' duration before advice was sought but, on careful enquiry later, it was found that the history should have covered at least two weeks and probably four weeks before symptoms were remarked by the owner. It is felt, therefore, that this must be classed as a late case, particularly in view of the result of the agglutination test.

27:12:46. Dog said to have been ill 48 hours. Dull; off food; passing small quantities of dark, tarry fæces frequently.

Temperature 102.4°F. Pulse rapid and thready. Abdominal palpation merely revealed diffuse tenderness and pain which could not be localised and was considered at this stage to be probably an enteritis of dietetic origin. Phthalyl-sulphathiazole was prescribed.

30:12:46. No improvement. No thirst or vomiting noted. The dog was now in very poor condition, tucked up and showing evidence of considerable pain on abdominal pressure; the expression was anxious, indicating the possibility of a peritonitis.

Leptospirosis was suspected and a blood sample taken in the belief, at this stage, that it would be an "early" sample. When a titre of 1:3,000 against *Leptospira canicola* was returned a more detailed examination of history was made and the facts previously mentioned elicited. In spite of the fact that it was obvious that the infection was both old-standing and more generalised than in the previous cases, it was decided to try penicillin and 250,000 units oily penicillin were given intramuscularly.

Penicillin therapy (125,000 units daily) was continued for nine days; there being a quite marked improvement in the dog's general health and spirits, in spite of progressive changes in liver, kidneys and pleuræ.

Jaundice developed on the third day of penicillin treatment and two days later the liver could be palpated behind the costal arch and this enlargement progressed until death occurred.

On the sixth day there was evidence of pleuritis and pericarditis and the icterus was now fading.

The dog continued to eat a little and was remarkably bright considering the tissue damage which had occurred. His condition gradually deteriorated, however, and death occurred on the ninth day after the commencement of penicillin therapy.

Post-mortem examination revealed inflammatory changes in kidneys, liver, pluræ and pericardium, all of which had been detectable in life. There was also evidence of recent acute pneumonia which was the actual cause of death.

B. A case in which cardiac symptoms were predominant. 1½ yrs. mongrel, m.

History.—Tiring after exercise some 2-4 weeks. For two days had been

collapsing several times daily on excitement or exertion. The attacks as described by the owner were apparently typical heart attacks. The dog had been seen at a welfare society clinic. Appetite was good and spirits normal except for early exhaustion. No vomiting.

Examination.—Temperature 101°F. Condition excellent. Absolutely nothing to be found on examination with the exception of a weak first heart sound.

Symptomatic treatment elicited no response, the attacks becoming more frequent.

Two weeks later the heart attacks were lessening in number but thirst had increased. The tongue was now slightly brownish and the mucous membranes anæmic. Urine showed Albumen +.

Blood sample.—*L. canicola* + 1 : 10,000.
L. ictero. + 1 : 300.

Penicillin therapy was instituted and rapid improvement occurred. In view of the duration of the case, 0.5 gm. streptomycin was given in two doses to obviate so far as possible residual kidney damage.

The probable explanation of the heart attacks in this case is that endocarditis was present to a marked degree. Lesions of chronic endocarditis have been found *post mortem* in cases of leptospirosis.

Another sample of blood was examined approximately 11 weeks after clinical recovery; the titres then were:

L. canicola + 1 : 300.
L. ictero. + 1 : 30.

The dog remains in normal health.

L. Icterohæmorrhagiæ Infection

The acute sporadic and enzootic form of leptospiral jaundice has already been described by Okell, Dalling and Pugh. In addition, the majority of cases seen by the author fall into the sub-acute group, and it is proposed to confine the present paper to a consideration of this type of case.

Sub-Acute

Both icteric and non-icteric syndromes occur in this group, the latter type so closely resembling sub-acute infections with *L. canicola* that differentiation on clinical grounds is usually impossible and the diagnosis of the strain involved has to be either (*a*) suspected when response to penicillin therapy is delayed or absent, or (*b*) diagnosed after repeated serum testing if the animals survive long enough.

(*A*) *Icteric Form*

Occurs sporadically and is ushered in by vomiting and depression. There is occasionally passage of blood-stained or tarry fæces in the early stage. Temperature is normally elevated to 102-105°F, falling to sub-normal by about the fourth day. A few small sub-mucous hæmorrhages may be found in the mouth. Thirst may be increased, but frequently fluids are refused; in both cases there is

relative anuria. Slight icterus may be noted on the fourth day and is usually fairly well marked by the sixth day. Prognosis in such cases is usually bad, although recovery occasionally occurs. Death ensues in 7-14 days, depending upon the severity of the case.

(*B*) *Non-icteric Form*

In this type of case the renal syndrome predominates and follows closely the course followed by sub-acute *L. canicola* infections. The most regular symptoms are occasional vomiting, depression and inappetence.

Temperature is usually elevated one or two degrees in the early stages but falls later. Discolouration of the mouth and tongue is common, as is a uræmic odour of the breath. Loss of condition and dehydration are progressive and are more regular features of this syndrome than of the corresponding *L. canicola* infection.

Icterus does not develop at any stage. The grossly enlarged kidney so typical of *L. canicola* infections may not be present although the left kidney is frequently palpable, slightly enlarged and more pendulous than normal. Prognosis in these cases is more grave than in the corresponding *L. canicola* group, death occurring from uræmia in a high proportion of cases after an illness lasting from six days to one month.

Case Records

The following cases are quoted as typical of the non-icteric syndrome since the icteric form is already sufficiently well recognised.

1. 6-7 yr. mongrel, m.

History.—Dullness and poor appetite. Had vomited two weeks previously. Progressive loss of flesh.

Examination.—Thin and tucked up. Mouth dirty but not uræmic. Temperature 100.2°F.

Leptospirosis canicolaris suspected. Penicillin therapy instituted.

Agglutination test.—1 : 1 : 48. *L. ictero.* + 1 : 100 ± 1 : 300.
L. canicola + 1 : 100 ± 1 : 300.
5 : 1 : 48. *L. canicola* trace 1 : 10 — 1 : 300.
L. ictero. + 1 : 300.

This rise in the titre to *L. ictero* and the fall of that to *L. canicola* was considered to be diagnostic of a current *L. icterohæmorrhagiæ* infection.

Response to penicillin in this case was slow but good and recovery followed.

2. 1½ yr. X. Terrier, m.

History.—2 : 1 : 48. Ill two weeks before presented. Vomiting, dullness, inappetence. No increase in thirst. Foul breath noted.

Examination.—Membranes pallid. Teeth and tongue brown, the typical non-uræmic type of odour was detected. The dog was thin and tucked up. Pulse fairly good. Left kidney palpable. Penicillin therapy instituted.

Agglutination test.—*L. canicola.* Traces 1 : 10 — 1 : 300.
L. ictero. + 1 : 3,000.

3 : 1 : 48. Deteriorating. Vomiting persisting. Increased thirst. Temperature 103.6°F. Buccal mucosa ulcerating, uræmic odour now present. Hidebound.

Urine.—S.G. 1,012. Acid. Trace of bile pigments. Alb. ++. Sugar —.

4 : 1 : 48. Was collapsed when presented for penicillin although the buccal ulcers were healing. The dog became comatose and died later that day.

Post-mortem Examination. Oral Cavity.—Teeth are covered with brown scum, but the tongue shows no ulceration or inflammation. Tonsils and submaxillary lymph glands normal.

Thorax.—Bronchi contain aspirated gastric contents (apparently terminal event). Lungs and associated lymph glands normal.

Peritoneal Cavity.—Liver, gall bladder, spleen normal. Pancreas congested and a number of petechiæ are present.

Alimentary Tract.—Œsophagus normal. Stomach: Acute, intense congestion throughout, but strictly localised to the stomach and not extending beyond the pylorus. Small intestine: A number of small mucosal erosions are present in the duodenum and jejunum. A few hæmorrhagic spots are present in the mucosa elsewhere in the small intestine, otherwise no change is present. No congestion is present in the small intestine. Large intestine: No change. Mesenteric and ileo-colic lymph nodes showed no change or deep congestion.

Urino-Genital System.—Kidneys: Normal size, capsules strip readily. On section the cortex appears very pale. Bladden, normal. Prostate, normal.

Cardio-Vascular System.—Pericardium: No change. Epicardium: Some petechiæ present over the right A-V groove. Heart: The left auricle endocardium shows superficial necrosis in the form of a pale membrane covering its surface. Some ante-mortem clot present in the left auricular appendix.

Microscopical Examination.—Kidney. (1) Patchy intertubular fibrosis throughout the inner part of the cortex, becoming more diffuse near the capsular surface; (2) Extensive non-suppurative pyelonephritis, many of the tubules containing proteinous material and disintegrated cells; cloudy swelling of the tubular epithelium and degeneration of the epithelial nuclei; (3) Intense round-celled infiltration of the inner cortex consisting almost entirely of plasma cells; (4) Glomeruli show swelling of the tufts and marked degenerative change of the glomerular capsule. Blood urea level = 126 mg. per cent.

3. 3 yrs. Wire Fox Terrier, m.

27 : 3 : 48.

History.—Illness of probably two weeks' duration with nebulous symptoms. Now vomiting, off food, dull. Increased thirst.

Examination.—Temperature 102°F. Grossly depressed. Temporal muscles atrophied. Friction sounds on auscultation indicative of dry pleurisy. Dorsum of tongue dry. Uræmic odour from mouth. Penicillin therapy instituted.

Agglutination test.—*L. canicola* + 1 : 30.
L. ictero. + 1 : 300.

28 : 3.48. Temperature 102°F. No improvement in general condition. Respiration painful. Less uræmic odour.

29 : 3 : 48. Temperature 99.6°F. Pulse imperceptible. Chest condition unchanged. Died later that day.

Post-mortem examination.—Carried out for attempt at culture of organism. Macroscopic examination only; no gross changes noted. An attempt was made to recover the organism from this case by inoculation of liver/kidney mush into hamsters but no strain was isolated.

Diagnosis

Diagnostic measures include: (1) The clinical syndrome; (2) examination of serum samples for the presence of specific agglutinins; (3) dark ground microscopy of urine; (4) blood culture; (5) dark ground microscopy of blood during the bacteriæmic phase; (6) culture from urine. To these methods the author would add the useful clinical guide of response to penicillin therapy in cases of *L. canicola* infection, realising that this can serve only as confirmatory evidence to clinical suspicion before the result of serum examination is available.

While appreciating the desirability of demonstrating the organism to establish diagnosis on a positive basis it is proposed here to consider the problem from the standpoint of the average clinician engaged in canine practice and with the usual indirect contact with a diagnostic laboratory. In this respect it is necessary to recall that the number of bacteriologists having the antigens available is extremely limited in this country, and it is therefore rarely possible for specimens to reach a laboratory within a few hours of collection.

The use of blood as a diagnostic medium, either for culture or demonstration of the organism, postulates the recognition of a high percentage of cases in the bacteriæmic stage, if indeed this occurs as a clinically recognisable state in every case. Culture of the organism from blood or urine cannot be accomplished on any ordinary media and necessitates the use of experimental animals for inoculation; in addition there must be a delay of 10-14 days before a strain can be recovered. In the author's view, therefore, this method is rarely practical.

Dark ground examination of blood is a matter for a bacteriologist highly expert in the recognition of leptospires, since many refractile bodies are seen in such a film and which may resemble the organism in many respects.

The examination of urine samples by dark-ground microscopy is held by Stuart and McIntyre to be a useful means of diagnosis well within the scope of the average clinician.

With this view the author cannot agree. Leptospires rapidly disintegrate in an acid medium, hence it is necessary either to examine the specimen immediately after collection or to use an appropriate buffer to achieve a suitable pH for the maintenance of the organism. The routine use of the catheter to obtain the necessary specimen may be justified under research conditions, but in ordinary

practice the use of this instrument to obtain diagnostic material cannot, in the author's view, be justified when other practical methods of diagnosis are available. Reliance cannot be placed upon the ordinary collection of urine by the owner or attendant. Furthermore, not all active cases of leptospirosis show leptospires regularly in the urine. The author has examined several negative specimens of urine which have shown refractile bodies likely to confuse any but the experienced bacteriologist.

In this connection it may be useful to quote so renowned an authority as Borg-Petersen on the subject of diagnosis of human leptospirosis. He says: "In practical diagnostic work we can isolate the leptospires from only a minority of cases. For the rest we must be content with the microscopical demonstration of leptospires in the urine and we must rely on the demonstration of specific antibodies."

The author submits that for the purpose of general practice diagnosis may be confidently based upon the clinical syndrome plus the examination of serum for specific antibodies. The universal acceptance of the specificity of the agglutination test for leptospirosis should be sufficient to warrant its forming the basis of clinical diagnosis. The collection of blood presents no difficulties; less than 1 c.c. of blood may suffice, although 2.5 c.c. is preferable. The specimen is obtained by the usual intravenous technique, under routine conditions of asepsis; the sample is allowed to clot and may then be posted to the laboratory. In urgent cases the result of the test is available within 36 hours.

The exhibition of, and response to penicillin is a useful practical aid to diagnosis for the clinician, although it is obviously of no significance from the bacteriological standpoint. The difference in the response to penicillin of *L. canicola* and *L. icterohæmorrhagiæ* may be useful in distinguishing the infecting species, often before the serological reaction has differentiated sufficiently to allow positive diagnosis of the organism involved.

Interpretation of the Agglutination Test

The clinician must have a reasonable understanding of the fundamental mechanism of agglutination reactions to enable him to interpret this in correlation with the symptoms displayed by the patient. Even so, certain aspects of this test must remain uncertain pending controlled experiments to determine certain factors, e.g., it seems ressonable to assume that, when specific therapy is instituted early in the course of leptospirosis, the killing of the organism will reduce antigenic stimulus. The eventual titre reached in such a case would therefore not be so high as that in cases where treatment commenced late, or in which spontaneous recovery following the natural course in a mild case has occurred. Without much more evidence than is at present available, however, such a supposition is impossible of proof.

Agglutinins appear in the blood of an infected animal in 7-10 days from the onset of symptoms; the titre in which agglutinins can be detected gradually rises, reaching a climax in some 4-6 weeks, subject to the proviso regarding

specific therapy already mentioned. If the animal does not die from the disease this titre gradually falls during the ensuing 6-12 months, but a low titre persists for the remainder of the animal's life. The persisting titre varies, in the author's view, according to whether the organism has been completely eliminated from the body or whether a few infected foci persist in the kidneys. During the early weeks of agglutinin formation there may be co-reactions between various species of leptospires; in this country only *L. canicola* and *L. icterohæmorrhagiæ* are involved. The serum may show agglutinins in equal titre to both organisms, but repeated serum examination at 7-10 days intervals will eventually show a drop in titre of the heterologous strain, while that of the invading species continues to rise. A titre ten times that of the heterologous strain is considered to be diagnostic of the infecting species.

The agglutination titres will vary according to the technique employed by the bacteriologist. For example, the use of living suspensions of leptospires results in agglutination at higher titres than when formalinised cultures are used; similarly the end point is taken by some workers to be that at which approximately half the leptospires are agglutinated in clumps, whereas others consider the end point should be the dilution in which any trace of agglutination remains. In the author's series the agglutination tests have been carried out by Dr. J. C. Broom using formalinised cultures and taking the titre at the point when half the organisms are agglutinated. Providing the clinician is guided by the bacteriologist as to the titres to be expected in given circumstances this difference in technique is of no account, but results should never be compared with those of other workers except when the technique is identical.

The ideal method of using the agglutination test for diagnosis of primary leptospirosis is to have two or more serum samples examined at intervals throughout the case. If the case is seen very early in its course serum should be negative for agglutinins, at 10-14 days' duration agglutinins should be present at titres of 1 : 100—1 : 300; this should rise rapidly and by the fourth or fifth week of illness the titres will be between 1 : 1,000 and 1 : 10,000.

Frequently, however, it is not possible to obtain repeated samples, owing to lack of co-operation from the owner in private practice, particularly if the animal has responded to specific treatment and is clinically normal within 10 days of first being presented. In addition the author considers that the early exhibition of penicillin or streptomycin will modify the characteristic rise in titre. It may therefore be necessary to base clinical diagnosis on the clinical picture, the result of the agglutination test on one blood sample, plus the response to penicillin or streptomycin in primary uncomplicated cases.

A dog presented with a history of 2-4 weeks' duration, with symptoms which lead to a diagnosis of nephritis, and whose serum shows agglutinins at a titre of 1 : 1,000 or more may confidently be regarded as a case of current leptospirosis. In dogs of over 5 years of age, with symptoms suggestive of chronic interstitial nephritis a diagnosis of primary leptospirosis should not be made unless the characteristic titre rise occurs during the first 6 weeks of illness; titres of

1 : 30-1 : 300 in such cases are suggestive of a previous infection which may have occurred years earlier.

A series of blood examinations on unselected dogs will be considered later, but it is necessary to state here that some 43 per cent of dogs show agglutinins to leptospires. Many of these animals are old dogs having no history of illness suggestive of leptospiral infection at any time in their lives, and no clinical evidence of renal dysfunction at the time of destruction. Titres in old dogs commonly lie between 1 : 10 and 1 : 300. The author regards those dogs having a titre of 1 : 10 or 1 : 30 as being subjects which have eliminated the organism from the body, but suspects that those retaining agglutinins at titres of 1 : 100-1 : 300 are cases where apparent clinical recovery has occurred but in which residual foci of infection remain in the kidneys.

Methods of Infection and Spread

The infective medium in cases of leptospiral infection is urine. It follows, therefore, that direct dog to dog transmission in the ordinary sense does not occur, but that indirect spread is usual via infected urine, water or damp ground. It is presumably possible that dogs excreting leptospires can infect others during coitus.

Wirth showed that a letospiruria could persist for 6 months following clinical recovery. Brion records a shedding of leptospires in urine 12 months past recovery, and if the author's interpretation of persisting titres of 1:100-1:300 is correct it follows that some dogs may be capable of shedding leptospires for the remainder of their lives. This picture is probably correct for *L. canicola*, which has no known animal reservoir other than the dog, but in the case of *L. icterohæmorrhagiæ* it seems that water and ground may be infected either from infected urine from other dogs or from rats, approximately 30 per cent of which are known to harbour this organism. That indirect dog to dog infection with *L. icterohæmorrhagiæ* can occur without the intervention of the rodent host is borne out by the author's experience of several cases arising over a period of weeks within a very circumscribed locality, in dogs which exercised or urinated over the same ground, but between which there was no direct contact. In this outbreak no trace could be found of rats anywhere in the particular locality.

It is known that certain species of non-pathogenic leptospires (*L. biflexa*) can exist in water and it seems probable that *L. canicola* has the same ability, at least for a period of months. *L. icterohæmorrhagiæ* can also survive outside the animal body for a period of up to 3 weeks. In many districts clinicians have been able to associated the distribution of cases of *L. canicola* infection with a given pond or stream, or even marshy ground in which the local canine population has been wont to disport itself. Even more specific evidence is provided by the experience of one owner who lost three dogs in fairly rapid succession (an interval of weeks) from so-called "Stuttgart disease"; in the last of these cases *L. canicola* was incriminated and there seems little doubt that the other two dogs had a similar infection. The source of infection in these cases was

almost certainly a pond in the garden which all these dogs were known to enter. (T. W. F. Pay, private communication.)

A striking feature is that in many cases of *L. canicola* infection it is possible to obtain a history of immersion in water, partial or complete, shortly before the development of symptoms, whereas dogs which confine themselves to drinking from the same water rarely develop infection.

Route of Infection

The ability of leptospires actively to penetrate skin and mucous surfaces is well known. The author considers that the relatively thick dermis of the dog probably provides a resistant barrier to infection, other than at specially modified points such as the interdigital fossa, and that infection in this species probably takes place by penetration of mucous surfaces, particularly those of the external genitalia.

The author's contention that infection frequently occurs via the external genitalia has been interpreted in many quarters as postulating an ascending infection of the urinary tract. That is not correct, the author's belief being that the site of entrance is the genital orifices and that from these sites penetration of the vulval, vaginal or preputial mucosa occurs, thus affording entrance to the body tissues. This hypothesis of entrance via the external genitalia is supported by the breed incidence (to be considered later), the frequent history of known immersion in water or a predilection on the part of the animal for entering water, the method of urination in the dog, and the occurrence of the great majority of cases in dogs which are sexually mature. All these factors predispose the external genitalia of the dog to contact with infected media, whether urine from a second dog or contaminated water, walls, ground, etc.

Age Incidence

Primary leptospirosis occurs mainly in dogs under 5 years of age. In the author's series few cases occurred under 1 year, the youngest being 9 months, although in this case the infection may have been of some 8-10 weeks' duration.

Primary leptospirosis in dogs over 5 years is uncommon, but attacks of sub-acute, or "flare-ups" of chronic nephritis attributable to an old-standing infection, are common.

Treatment

L. canicola infection.—This organism is highly susceptible to two antibiotics, both now available to the veterinary surgeon, viz., penicillin and streptomycin.

Clinically, the response of *L. canicola* cases to penicillin is little short of dramatic, and it is probably true to say that recovery from the current infection may be expected in all cases where treatment is commenced reasonably early, and even in late primary cases if widespread tissue damage in organs other than the kidneys has not occurred. Penicillin therapy should be continued for

a minimum of 6 days; if treatment is stopped before this period, relapse is common, even in dogs which have made an apparent clinical recovery in less than that time.

In a number of cases in which clinical recovery from acute or sub-acute leptospirosis followed penicillin therapy, and in which apparently normal health was restored, certain signs persisted indicating that some renal dysfunction remained. Persisting indications of renal damage include increased water intake, failure of the buccal mucosa and tongue to return to complete normality, faint uræmic odour from the mouth, and changes in the urine, notably low specific gravity and a slight albuminuria. At first it was thought that these cases were due to relatively long-standing infection (histories of 4-6 weeks' duration are not uncommon in sub-acute cases) resulting in damage to the renal tissue before treatment was sought or instituted. The work of Brunner and Meyer has, however, thrown a different light on this problem. These workers showed that, in experimentally infected animals, while penicillin cleared the blood stream of leptospires and saved the lives of the animals, organisms were still to be found in the convoluted tubules and continued to be shed in the urine. Streptomycin, on the other hand, freed the kidneys and the urine from infection. This observation the author has been able to confirm clinically (in the case of *L. canicola* infection) during the very limited time it has been possible to use streptomycin.

One case which may be quoted was that of a 1-year-old Scottish Terrier male, presented with a history of definite illness of 1 week's duration, but the owners maintained that the dog had not been normal for nearly 6 months. Penicillin therapy was commenced at once and the dog made considerable clinical improvement. The blood titre was 1 : 10,000, indicating an infection of some 6 week's + duration; urine showed albumen +, S.G. 1,026. Penicillin was administered over a period of 8 days, at the end of which time the dog was in reasonably good health but a uræmic odour persisted, as did slight albuminuria. Fourteen days later the clinical picture was unchanged. Streptomycin was given 3 weeks after the cessation of penicillin treatment. Dosage was a total of 1 gramme, administered over a 3-day period. Considerable clinical improvement followed very rapidly, and 1 week after the finish of treatment the uræmic odour had disappeared, the dog was clinically normal, the albuminuria was no longer present, and urine density had increased to 1,042. At the time of writing (3 months later) the dog appears normal in every respect.

In view of the lack of experience in the use of streptomycin in small animals in this country and to the possibility of toxic symptoms such as those occurring in man, the author has adopted the course of administering penicillin for a period of 4 or 5 days, followed by streptomycin for a period not exceeding 3 days.

Symptomatic treatment may be necessary in some cases as an ancillary to antibiotics, but such treatment is of a routine nature and needs no description here.

L. icterohæmorrhagiæ infection.—The response of this organism to peni-

cillin is disappointing. A proportion of cases shows response to the drug, but this is not so spectacular as in *L. canicola* infection, nor is it so rapid. Failure of a case diagnosed as primary leptospirosis to respond to penicillin within 48 hours is a useful indication of the species of organism involved, and may serve as a differential diagnostic measure some days before the agglutination test indicates the invading strain. In such cases anti-*Leptospira icterohæmorrhagiæ* serum should be given, but in the author's hands it has not proved of much value in the sub-acute, renal type of case considered here.

Brunner and Meyer record that streptomycin was equally effective against this species; this the author has so far had little opportunity to confirm. One case only can be quoted, and diagnosis was made purely on clinical grounds as the dog died before serological methods could have been used and the body was not available for an attempt to isolate the organism. The case in question was of an icteric type, and streptomycin was given on the 4th day of illness, when icterus was showing definitely but slightly for the first time. The drug had no effect on the course of the disease, and death occurred on the 6th day.

The routine use of streptomycin in leptospirosis cases failing to respond to penicillin in 48 hours is obviously to be recommended.

Prophylaxis

Vaccines for both *L. canicola* and *L. icterohæmorrhagiæ* are available, the former only recently.

The author has no experience of their use. Results in the field could probably only be assessed by comparing percentages of reactors in series of vaccinated and unvaccinated dogs.

The recommendation to vaccinate dogs living in areas in which cases of infection are relatively frequent, or dogs of breeds of known high susceptibility (e.g., Scottish Terrier), is undoubtedly justified. Assuming that vaccination will reduce the number of dogs shedding leptospires in their urine, prophylactic measures are also desirable on public health grounds.

Association of Leptospirosis with Chronic Interstitial Nephritis of the Dog

There can be no doubt that infection with leptospires, especially *L. canicola*, plays a great part in the production of chronic nephritis in the dog. Equally, it would be wrong to assume that all renal disease in the dog is associated with a current or past leptospirosis.

The author now divides chronic nephritis cases into two broad clinical groups without reference to the specific pathology. Differentiation is based on the degree of protein loss as indicated by routine urine examination for the detection of albumen.

Since this paper does not set out to discuss canine nephritis as such, only broad clinical features will be indicated.

1. *Cases of low protein loss.*—Those in which the symptoms comprise vomiting, increased thirst, poor appetite, some loss of condition, dullness, uræmic

odour from the mouth, and ulceration of the buccal mucosa. Urine examination of this type of case usually shows decreased specific gravity, often as low as 1,005, and a low or moderate degree of albuminuria indicated as ±, + or ++.

Such cases frequently respond to routine therapeutic measures and dietetic adjustment, and a reasonable standard of general health may be maintained for a period of months or even years before recurrence of active symptoms, although an examination of the patient will show evidence of renal insufficiency. The onset of clinical symptoms in these dogs can often be related to some lowering of resistance from sudden change of temperature, wetting, etc. These cases progress through one or more clinical attacks of nephritis until death supervenes from renal failure. Blood urea concentration is raised. Remissions and exacerbations in the clinical picture are characteristic of this group.

2. *Cases of high protein loss.*—In these cases changes in the dog's condition are often noticeable long before active symptoms draw the owner's attention to the disease.

Loss of muscle tissue is very marked, particularly about the head. Appetite and spirits frequently remain unchanged until the terminal phase. Vomiting is not frequent. There is commonly increased thirst, although this is not invariable. The mouth usually shows considerable recent deposits of soft calculus on the teeth and there is a foul odour not necessarily uræmic in type. Softening of the bones of the mandible is not uncommon. So-called uræmic convulsions may occur.

Urine output is not always increased, although specific gravity is usually below normal. High protein loss is indicated as +++ or ++++, the specimen occasionally becoming semi-solid on the addition of sulphosalicylic acid.

These cases usually show steady deterioration in physical condition, and exhibit none of the exacerbations and remissions of the previous type.

Blood urea concentration is also raised.

In the author's experience a high proportion of cases falling into category 1 show agglutinins to leptospirosis, many at titres of 1 : 100-1 : 300, and in the light of the similarity between the pathology of these cases and that of cases of young dogs which have been destroyed following incomplete recovery from primary leptospirosis, it seems reasonable to assume that this infection is of some ætiological significance.

On the other hand, a number of cases falling into category 2 are negative for anti-leptospiral agglutinins. The author feels that much work remains to be done before the true significance of leptospirosis in the production of canine renal disease can be assessed; likewise, to place reliance solely upon correlation between reactors and raised blood urea levels may not give a true picture of the situation.

Since recognising canine leptospirosis as a clinical entity and the value of penicillin in its treatment, no case of primary *L. canicola* infection has been

lost, hence no post-mortem findings are available to indicate the pathological changes occurring early in the disease.

Two post-mortem reports of cases destroyed and dying as a result of recurring attacks of nephritis following incomplete recovery from an attack of leptospirosis are appended. The chronic interstitial nephritis found even in young dogs in this type of case is identical pathologically with the long-recognised chronic interstitial nephritis of the old dog.

On so slender a foundation it may not be too much to express the view that the increasing early recognition, adequate treatment, and possibly prophylaxis, in cases if primary leptospirosis, must lead to a decrease in the incidence of chronic nephritis in the old dog. So far as acute and sub-acute nephritis in young dogs is concerned, it is the author's view that leptospiral infection is the cause in the great majority of cases—an exception being the occasional case of pyæmic nephritis, a condition which is usually diagnosed *post mortem* following an ill-defined train of symptoms, and which clinically bears no resemblance to nephritis of leptospiral origin.

1. 2-YEAR-OLD ALSATIAN MALE

General.—The carcase showed emaciation but no dehydration.

The *mouth* showed browning of the tongue and ulceration of the mucosa of the cheek.

Alimentary canal.—The stomach was congested. No change in œsophagus; the remainder of the intestines were not examined.

Respiratory system.—No change.

Cardiovascular system.—Extensive healed lesions of necrotising endocarditis and arteritis affecting the left auricle, aorta and pulmonary trunk. Cardiac hypertrophy was present.

The *kidneys* showed increased fibrous tissue within the cortex and a very granular surface.

All *other organs* normal.

The *kidneys,* histologically, showed extensive diffuse interstitial fibrosis, distortion of glomerular tufts and capsular dilation of the glomeruli. There was a small area of active inflammation with scattered groups of polymorphs and young fibroblastic granulation tissue. Elsewhere, there was dense focal round-celled infiltration. Severe hypertensive hyalinisation of the glomeruli and arteries were present. The medulla showed fibrosis and metaplasia of the collecting tubules.

Agglutination tests:—

July, 1948, at time of current leptospirosis—

L. canicola + 1 : 1,000

L. ictero. + 1 : 100.

November, 1949, at destruction—

L. canicola + 1 : 100.

Case 1 was that of an Alsatian dog, first seen by the author at the age of

approximately 10 months, when he had been in his owner's possession only 1 month. The history in the circumstances was indefinite, but at the time of examination the dog presented a typical picture of sub-acute leptospirosis which was assessed as of 1 month + duration. Response to penicillin was good but incomplete, evidence of renal insufficiency persisting. During the 16 months intervening between this treatment and destruction the dog had shown intermittent evidence of nephritis. When destroyed he was showing all the signs of chronic nephritis as commonly seen in the old dog. It will be noted from the post-mortem report that extensive changes of typical chronic interstitial nephritis were present, together with evidence of recent active inflammatory changes, a combined picture which is easily correlated with the clinical history.

2. 11-YEAR-OLD WEST HIGHLAND TERRIER MALE

Post-mortem findings.—The animal was in fair general condition; there was no external abnormality.

Mouth and pharynx.—The teeth were heavily tartared. There was ulceration of the edges of the tongue. Tonsils normal; submaxillary lymph node somewhat congested.

Respiratory system.—Some pulmonary œdema; some congestion of the bronchial and mediastinal lymph nodes.

Cardiovascular system.—No change.

Alimentary system.—No change.

Liver and gall bladder.—No change.

Pancreas.—No change.

Spleen.—Very soft and congested.

some increase in the amount of fibrous tissue in the cortex.

Urinogenital system.—The kidneys showed no gross alteration, apart from *Ureters, bladder* and *prostate* were unchanged.

Endocrines.—A cortical adenoma in the medulla of the right adrenal. Thyroids normal.

Histologically, the *liver* showed intense sinusoidal engorgement and patchy severe fatty change. Some staining of the liver cells by bile pigment.

The *kidneys* showed intertubular fibrosis of long standing in the cortex. Superimposed upon this, however, there was evidence of more recent acute inflammatory change with plasma cell infiltration and occasional histiocytes and polymorphs in the interstitial tissue. The medulla showed no change.

The blood urea at death was 220 mg. per cent.

Case 2 is of some interest in that the author believes that the primary attack of leptospirosis occurred in 1942, but was not recognised as such. The terminal illness, which resulted in destruction, was typical of an acute "flare-up" of a long-standing chronic nephritis. The high titre of the agglutination test at the time of destruction was therefore unexpected; this was *L. canicola* + 1 : 1,000, *L. ictero.* + 1 : 30. In the light of the post-mortem report, which indicates superimposed active inflammatory changes upon an intertubular fibrosis of long

standing, the author suggests that in this case there was an actual recrudescence of bacterial activity resulting in a terminal rise in agglutinin titre.

It is submitted that these two cases, one in an old and one in a young dog, offer confirmation of the ætiological role of leptospiral infection in the production of chronic nephritis.

Cats

In view of the part played by the rodent population in acting as a reservoir for some species of leptospires, it was considered possible that cats might show evidence of invasion and/or infection.

Several cases of jaundice in cats have been investigated fully, but no leptospires have been incriminated.

A series of bloods from unselected cats destroyed for a variety of conditions has been examined. Ten per cent of these show agglutinins in low titre only, mainly to *L. icterohæmorrhagiæ*, but in one case to *L. grippotyphosa*. In no case as the titre exceeded 1 : 30.

In view of the fact that 90 per cent of these sera are quite negative, it is felt that it is safe to conclude that the reactors have been invaded by leptospires, and that the reaction is specific. In view of the absence of active clinical cases and titres higher than 1 : 30, it is felt that in no case has the organism caused clinical disease.

Public Health Considerations

Since disease occurs in man from infection by both *L. icterohæmorrhagiæ* and *L. canicola*, it is necessary to consider the relationship between human and small animal infection. The position regarding *L. icterohæmorrhagiæ* infection in man is already well understood; that concerning *L. canicola* differs, however, in that the dog is the only known natural host.

The disease caused by *L. canicola* in man is usually called canicola fever, and is a mild influenzal type of illness, often with meningeal symptoms. Only one fatal case has been recorded in this country. The first recognised case of human *L. canicola* infection occurred in 1946, and was the only case detected in that year. In 1947 four cases were diagnosed, in 1948 twelve, and in 1949 twenty-four cases were confirmed (Broom, private communication). It is believed that these figures do not reflect an increasing incidence of the infection, but merely an increasing recognition of the syndrome.

Human infection may arise indirectly or directly from the urine of actively diseased or recovered shedder dogs. Direct infection only arises where an owner is in contact with the infected urine, and such cases will obviously be limited to those instances in which an owner or attendant is nursing a sick dog which is urinating indoors during the course of the illness, or where constant mopping-up of urine is necessary where the dog has persistently dirty habits.

Indirect infection will arise from immersion in contaminated water, i.e., bathing in pools or streams to which dogs have access.

From the foregoing remarks it is clear that there is little need for an alarmist view of the possibility of dog-to-man transmission of infection. None the less, in any case where the possibility of transmission of disease from dog to man exists, the veterinary surgeon in attendance has a public health duty. In the case of direct infection, the advice to wear rubber gloves when dealing with urine and urine-contaminated bedding from a dog suspected of *L. canicola* infection should be sufficient to minimise the risk. In the case of indirect infection, discrimination in the choice of bathing-places is the obvious safeguard. As previously mentioned, successful vaccination of the dog population would presumably limit and progressively decrease the number of potential shedder dogs and would thus decrease the risk of human infection.

In the light of the very low titres of feline reactors to *L. icterohæmorrhagiæ*, it seems reasonable to assume that the potential shedder period in infected cats is of short duration and that the danger of human infection from these animals is slight.

Acknowledgments

My thanks are due first and foremost to Dr. Broom, not only for his collaboration in carrying out the agglutination tests, but for his unfailing patience and helpful advice throughout the period I have been interested in leptospiral infections.

I also wish to acknowledge the courtesy of H. Platt, B.V.Sc., M.R.C.V.S., in allowing me to incorporate in this work his post-mortem reports on several cases of leptospirosis quoted. Finally, I should like to acknowledge the help I have received from many of my colleagues who have so freely discussed this subject with me and who have placed clinical cases at my disposal which have materially increased my observations in this field.

Clinical Deductions from the Results of Examination of 155 Unselected Sera

The series of sera examined comprises a reasonably unselected group of dogs, suffering from or destroyed for a wide variety of conditions including leptospirosis, plus some sera from clinically normal dogs destroyed for personal reasons.

The author wishes to make it clear that the figures given in some sections may not tally with the over-all figures, since some sections have been expressed as over-all figures, whereas in others correction has been made in several cases for those individuals where repeat samples were examined.

REACTORS

In view of the specificity of the agglutination test in dogs, all sera showing any trace of agglutinins have been classified as reactors, this term indicating invasion by leptospires at some time during the animal's life, but not necessarily that clinical disease has occurred.

Of the total of 155 sera examined, 65 showed agglutinins to one or other species of leptospira, i.e., 42 per cent. Ratio of *L. canicola* to *L. ictero-*

hæmorrhagiæ reactors (corrected as far as possible for repeat samples): 44 were reactors to *L. canicola*, 12 to *L. icterohæmorrhagiæ*, and 5 were indefinite, showing para-agglutination at equal titres. Thus the ratio of reactors in the author's district is approximately 4 *L. canicola* to 1 *L. ictero*.

Sex Incidence

The series examined included 95 dogs and 57 bitches. Of these, 44 dogs were reactors (i.e., 45 per cent) and 16 bitches (i.e., 30 per cent).

These figures show some bias in favour of male infection, but the difference does not appear to be sufficiently well defined to warrant any conclusion as to relative sex susceptibility.

Age Incidence

Age incidence has been considered in four arbitrary groups, viz.: (1) under 6 months, (2) 6 months to 1 year, (3) 1 to 5 years, and (4) over 5 years. Some could not be classified owing to absence of information.

In *Group 1* there were no reactors.

In *Group 2* there were 5 reactors, of which 4 were active cases of leptospirosis.

Group 3 included 12 reactors, of which 8 were active cases of leptospirosis, 3 were suspected but not confirmed, and 1 only was not even suspected of current leptospiral infection.

Group 4 included 42 reactors, of which only 2 were considered to be cases of primary leptospirosis; 1 dog was suspected and 2 further cases were considered to be disease due to leptospiral infection but not primary leptospirosis. The clinical history of several reactors in this group has been known to the author throughout their lives, yet no illness has occurred which, even in retrospect, could conceivably have been leptospirosis.

From these figures it may be concluded that primary leptospirosis is essentially a disease of the young adult dog, occurring mainly within the ages of 10 months to 4 years. Occasionally primary disease occurs in the older dog, and instances are on record when young puppies have acquired infection very early in life from an infected dam; but, broadly speaking, clinical infection is most likely to occur in the sexually mature adult below middle life. This would support the suggestion that the route of infection is via the external genitalia since, on the one hand, young puppies are rarely allowed freedom of access to ponds, streams, etc., nor do they indulge in investigation of the genitalia of other dogs, nor of posts, walls and so on where other dogs have urinated. The middle groups of young adults, however, are prone to infection from all these sources, whereas the older dogs are becoming less sexually active, less inclined to enter water, and in addition have had greater opportunity of contact with leptospires, possible sub-clinical infection, and may thus have a naturally acquired immunity to primary disease.

XUM

Breed Incidence

Breed incidence was as follows:—

	Reactors	Males	Females
Mongrels	13	9	4
Scottish Terriers	11	6	5
Spaniels	8	5	3
Fox Terriers	7	5	2
Collies	3	2	1
Pekingese	2	0	2
Sealyham Terriers	2	2	0
Pomeranians	2	2	0
Alsatians	1	1	0
Chow Chows	1	1	0
Cairn Terriers	1	1	0
Airedale Terriers	1	1	0
Dachshunds	1	1	0
Bulldogs	1	1	0
West Highland Whites	1	1	0
Irish Setters	1	0	1
Bull Terriers	1	1	0
Dalmatians	1	0	1
Retrievers	1	1	0

The breed figures probably reflect mainly the relative popularity of breeds seen in a given practice, and a far larger survey would be needed to give a true statistical picture of breed incidence. On general lines, however, the figures do indicate some degree of increased breed susceptibility in the Scottish Terrier, and the bitch reactors show some bias in favour of breeds which are low-to-ground or carry a heavy feather or whisker round the external genitalia, predisposing to soiling of this hair by contaminated water, and so exposing the vulval and vaginal mucosa to infection.

It is of interest to note that, so far as can be ascertained from the history of the dogs under consideration, no dog deriving from kennels has been found to be a reactor; this is probably due to the controlled management of kennel dogs, with relative lack of opportunity to acquire infection as compared with the average household pet which, even if not allowed to roam the street at will, is usually exercised regularly over ground which is in similar use by most of the local dogs.

No.	Age	Sex	Breed.	L.Canicola	Titre(if +)	L.icterо	Titre(if +)	Disease or cause of destruction.
1	2½ yrs.	F	Scottish Terrier	+	1:3,000	-	+	Leptospirosis.
2	5-6 yrs.	M	Scottish Terrier	+	1:3,000	-	-	Leptospirosis.
3	10 yrs.	F	X Collie	-		-		Cerebral haemorrhage.
4	1 yr.	M	Cocker Spaniel	+ -	1:10 & 1:30	-		Suspected leptospirosis.
5	12 yrs.	F	Smooth Fox Terrier	-		-		Heart disease.
6	6 yrs.	F	Scottish Terrier	+	1:30	-		Sub-acute nephritis.
7 (137)	9½ yrs.	M	Scottish Terrier	-		-		Operation case.
8	12 yrs.	M	Alsatian	-		-		General senility.
9	4½ yrs.	F	Mongrel	-		-		Heart disease.
10	4½ yrs.	M	Pekingese	-		-		Heart disease.
11	12 weeks.	M	Mongrel	-		-		Destroyed.
12	12½ yrs.	F	Airedale	-		-		Pyometra.
13	10 yrs.	M	Cairn Terrier	-		-		Chronic nephritis.
14	Aged	M	Wire Fox Terrier	-		-		Chronic nephritis.
15	13 yrs.	M	Spaniel	+	1:30	-		Heart disease.
16	14 yrs.	M	Airedale	-		-		Senile collapse.
17	10 weeks.	M	Scottie	-		-		Rickets.
18	16½ yrs.	M	Pekingese	-		-		Heart disease.
19(1)	3½ yrs.	F	Scottish Terrier	+	1:100 tr.1:300	+	1:10	& neoplasia. Leptospirosis.
20	13 yrs.	F	Mongrel	-		-		Heart disease.
21	10 yrs.	M	Chow	-		-		Normal.
22	11 yrs.	M	Retriever	-		+	tr.1:10	Heart disease.
23	14 months.	F	Scottish Terrier	-		-		Normal.
24	9 yrs.	M	Spaniel	+	1:10 tr.1:30	-		Acute nephritis.
25	6-7 yrs.	M	Mongrel	+	1:300	+	1:300	Suspected leptospirosis.
26	1½ yrs.	M	Terrier	+	tr.1:10 - 1:300	+	1:3000	Clinical leptospirosis.
27	6 months	M	Terrier	-		-		Distemper; nervous symptoms.
28	6-7 yrs.(25)	M	Mongrel	+	tr.1:10 - 1:300	+	1:300	Retest of 25.
29	9 yrs.	F	Mongrel	+	1:30	-		Salivary cyst.
30	6 yrs.	F	Pekingese	-		-		Cystic calculus.
31	2 yrs.	M	Dachshund	-		-		Street accident. Fracture.
32	6 months.	M	Mongrel	-		-		Street accident.
33	Adult.	M	Mongrel	+	1:30	-		Distemper; nervous symptoms.
34	9 months.	F	Spaniel	-		-		Heart disease.
35	12 yrs.	M	Collie	+	1:30	-		
36 (25&26)	6-7 yrs.	M	Mongrel	+	1:100 tr.1:300	+	1:100	Leptospirosis.
37	11 yrs.	M	Chow	+	1:100	-		Torsion of stomach.
38	15 yrs.	M	Terrier	+	1:100	+	1:10	Heart disease.
39	1 yr.	F	Dachshund	-		-		Normal.
40	10 weeks.	M	Scottish Terrier	-		-		? Distemper.
41	14 yrs.	F	Cocker Spaniel	-		-		Senility.
42	3 yrs.	M	Scottish Terrier	+	1:30 tr.1:100	+	1:30	Suspected leptospirosis.
43	4 yrs.	M	Mongrel	-		-		Normal.
44	13 yrs.	M	Scottish Terrier	-		-		pseudo-Hodgkins disease.
45	10 yrs.	F	Mongrel	-		-		Abscess of neck.
46	11 yrs.	F	Mongrel	-		-		Dental abscess.
47	9½ yrs.	F	Scottish Terrier	-		+	1:10 tr.1:30	Rectal structure.
48	10 yrs.	M	Mongrel	+	1:300	+	tr.1:10 & 1:30	Normal.
49	Adult.	M	Terrier	-		-		Skin disease.
50	12 yrs.	M	Cairn	+	1:10	+	1:10	Heart disease.
51	9 yrs.	F	Samoyed	-		-		Jaundiced.
52	4 yrs.	M	Airedale	+	1:1000	+	1:30	? Leptospirosis.
53	5 months.	M	Fox Terrier	-		-		Distemper; nervous symptoms.

No.	Age	Sex	Breed	L.Canicola	Titre(if +)	L.Icterо	Titre(if +)	Disease or cause of destruction.
54	11½ yrs.	F	Scottish Terrier	-		-		Neoplasia.
55	11 yrs.	F	Irish Setter	-		+	1:30	Pyometra.
56	4½ months.	F	Mongrel	-		-		Post-distemper: nervous symptoms.
57	2 yrs.	M	Terrier	+	tr.1:10	+	1:30 tr.1:30	Muscular stiffness, one month previous.
58	1 yr.	M	Cairn	-		-		Street accident.
59	15 months.	M	Mongrel	-		-		? Leptospirosis.
60	1 yr.	F	Corgi	-		-		Fits.
61	14½ yrs.	M	Pomeranian	+	1:30	-		Heart disease.
62	5 months.	M	Mongrel	-		-		Street accident.
63	9 weeks.	F	Terrier	-		-		Vicious.
64	14 yrs.	M	Sealyham	+	1:30	-		Heart disease.
65	3 yrs.	M	W.H. Terrier	+	1:30	+	1:300	? Leptospirosis - died.
66	5 months.	M	Spaniel	-		-		Rickets.
67	13½ yrs.	M	Spaniel	+	1:300	+	tr.1:10	Chronic nephritis.
68	13 yrs.	F	Pekingese	-		-		Senility.
69	11 yrs.	F	Scottish Terrier	+	1:30	+	1:10	? Recent leptospirosis.
70	4 yrs.	F	Spaniel	-		-		Poisoned.
71	10 months.	M	Spaniel	-		-		Normal.
72	1 yr.	M	Mongrel	-		-		Distemper; nervous symptoms.
73	3 yrs.	F	Pekingese	+	1:30	-		? Leptospirosis.
74	13 yrs.	M	Scottish Terrier	+	1:300	+	1:100	Heart disease and nephritis.
75	14 yrs.	F	Cairn	-		-		Heart disease and nephritis.
76	3 yrs.	M	Mongrel	+	1:30	+	1:30	Normal.
77	12 yrs.	M	Scottish Terrier	+	1:30	-		Nephritis.
79 (52)	4 yrs.	M	Airedale	+	1:300	+	1:10	Leptospirosis.
80	11 yrs.	F	Collie	+	1:300	+	1:10	Heart disease and nephritis.
81	10 months.	M	Alsatian	+	1:1000	+	1:100	? Leptospirosis.
82	1 yr.	M	Sealyham	-		-		Normal.
83	10 yrs.	F	Mongrel	-		+	1:30	Uterine haemorrhage.
84	4 yrs.	M	Mongrel	-		+	1:300	? Leptospirosis Nephritis - destroyed.
85	6 yrs.	M	Mongrel	-		-		Nephritis.
86	10 months.	M	Collie	+	1:1000 (at least)	+	1:100	? Leptospirosis.
87	15 yrs.	M	Wire Fox Terrier	+	1:10 tr.1:30	-		General bad condition.
88	13 yrs.	M	Terrier	-		-		Heart disease.
89	11 yrs.	F	X Terrier	-		-		Heart disease.
90	11 yrs.	F	Cocker Spaniel	-		-		Senility.
91	13yrs.	F	Mongrel Terrier	-		-		Senility.
92	13 yrs.	F	Spaniel	-		+	1:10	Senility.
93	9 yrs.	F	Pekingese	+	1:100 tr.1:300	+	1:10	Acute cystitis.
94	Adult.	F	Spaniel	-		-		Tuberculosis.
95	11 yrs.	F	Wire Fox Terrier	-		-		Heart disease.
96	12½ yrs.	M	Scottish Terrier	+	1:300	-		General senility.
97	14½ yrs.	M	Wire Fox Terrier	+	1:30	-		Heart failure.
98	14 yrs.	M	Wire Fox Terrier	-		-		Senility.
99	6 yrs.	F	Scottish Terrier	+	1:300	-		Leptospirosis.
100	16½ yrs.	F	Mongrel	+	1:30	-		Senility.
101	4 yrs.	F	Wire Fox Terrier	-		-		Chronic skin trouble.
102	10 yrs.	M	Mongrel	+	1:300	+	1:100	Leptospirosis 1 month's duration.
103	11 yrs.	M	Wire Fox Terrier	-		-		
104	2 yrs.	M	A-breed Terrier	+	1:100	-		Mild leptospirosis, 2½ weeks ago.
105	12½ yrs.	F	Cocker Spaniel	-		-		
106	7 months.	M	Mongrel	-		-		Fits.
107	13 yrs.	F	Wire Fox Terrier	+	1:300	+	1:30	Heart disease and nephritis.
108	12 yrs.	F	Chow	-		-		Arthritis.

No.	Age.	Sex	Breed	L.Canicola	Titre(if +)	L.ictaro	Titre(if +)	Disease or cause of destruction.
109	9 yrs.	F	Cocker Spaniel	-		+	1:100	Jaundice in July, 1946.
110	12 yrs.	F	Scottish Terrier	-		-		Cardiac arcites.
111	9 yrs.	F	Spaniel	+	1:30	-		
112	15 yrs.	F	X-bred Pomeranian	-		-		Heart disease and uraemia.
113	15 yrs.	M	Smooth Fox Terrier	-		-		Neoplasia.
114	11 yrs.	M	Cocker Spaniel	+	1:100	-		Neoplasia.
115	1 yr.	M	Alsatian	-		-		Hard Pad.
116	13½ yrs.	M	Mongrel	-		-		Senility.
117	3 yrs.	F	Chow	-		-		Temperament.
118	13 yrs.	F	Mongrel	-		-		Diabetes.
119	6 yrs.	M	Bull Terrier	-		-		Nephritis.
120	8 months.	M	X-bred Terrier	-		-		Hard Pad.
121	13 yrs.	M	Wire Fox Terrier	-		-		Heart disease.
122	3 yrs.	M	Bull Terrier	+	1:30	+	1:10	Nephritis - ? 1 week.
123	6 yrs.	M	Scottish Terrier	-		-		Albuminuria.
124	9 + yrs.	M	X-bred Pomeranian	+	1:100	-		Ear Trouble.
125	10 months.	F	Mongrel	-		-		Street accident.
126	7 yrs.	F	Dalmatian	+	1:30	+	1:30	Skin trouble.
127	13 yrs.	F	Wire Fox Terrier	+	1:300	+	1:10	Pyometra.
128				-		-		
129	4 months.	M	X-bred Boxer	-		-		Hard Pad.
130	3 yrs.	F	Chow	-		-		Chronic skin trouble.
131	10 yrs.	M	Sealyham	+	1:300	+	1:10	Enlarged liver and severe albuminuria.
132	1 yr.	M	Alsatian	-		-		Street accident.
133	12 yrs.	F	Spaniel	-		-		Staph. infection.
134	?	M	Retriever	+	1:100	-		Stray.
135	1 yr.	M	Scottish Terrier	+	1:10,000	+	1:100	Leptospirosis.
136	7 yrs.	F	Mongrel	+	1:30	+	1:10	Pyometra.
137	11½ yrs.	M	Scottish Terrier	-		-		Heart disease.
138	6 yrs.	M	Dachshund	+	1:10	+	1:100	? Leptospirosis.
139	6 yrs.	M	Dachshund	-		+	1:100	Repeat of 138.
140	18 months	M	Mongrel	+	1:10,000	+	1:300	Albuminuria.
141	14 yrs.	M	Mongrel	-		-		Heart disease and nephritis.
142	1 yr.	M	Bulldog	+	1:10	+	1:10	
143		M	Bull Terrier	-		-		Epileptic.
144	6 yrs.	M	Cocker Spaniel	-		-		Liver disease.
145	2 yrs.	M	Alsatian	+	1:100			Recurring nephritis.
146	11 yrs.	M	Cocker Spaniel	-		-		Albuminuria.
147	2 yrs.	M	X-bred Terrier	-		-		
148	17 yrs.	M	Pekingese	-		-		Heart disease.
149	13 yrs.	M	X-bred Terrier	-		-		Senility.
150	11 yrs.	M	W. Highland Terrier	+	1:1000	+	1:30	Heart disease and nephritis.
151	15 yrs.	F	X-bred Terrier	-		+	1:10	Neoplasia.
152	Aged.	F	Wire Fox Terrier	-		-		Neoplasia.
153	12 yrs.	M	Mongrel	+	1:300	+	1:30	Recovered case.
154	7 months.	M	Elkhound.	-		-		Street accident.
155	7 months.	M	W. Highland Terrier	-		-		Normal.

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SOME RECENT ADVANCES IN THE GENERAL ANÆSTHESIA OF THE DOG*

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1. Introduction

THE history of veterinary anæsthesia is as old as anæsthesia itself. Thus Duncum (1947) records that in 1824, Henry Hill Hickman published his first report on the effects of re-breathing upon young dogs. Morton (Fig. 1) carried out his first experiments with ether on a pet spaniel in 1846. John Snow (1813-1858) is reported to have employed closed circuit anæsthesia on animals. Spinal anæsthesia was first produced in a dog by Corning in 1885.

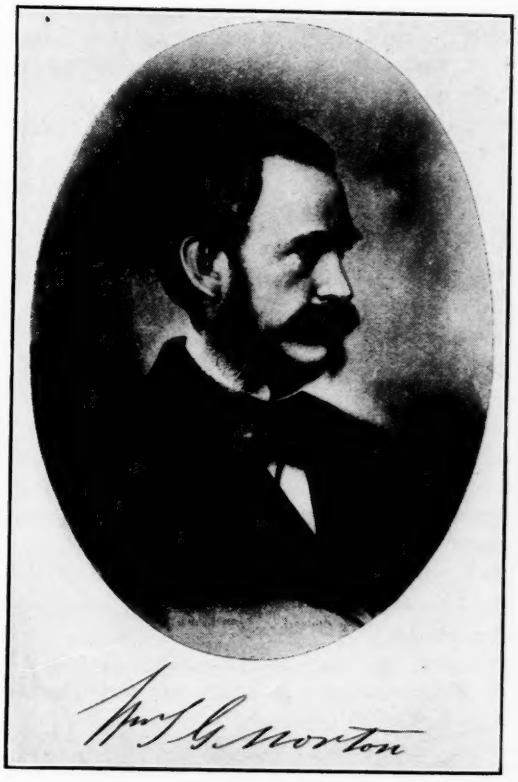
Recent advances in the methods employed for the general anæsthesia of the dog are few and far between. Nothing new has come into anything like general use since the introduction of the barbiturates pentobarbitone ("Nembutal") and thiopentobarbitone ("Pentothal") in 1931 and 1933 respectively. On the other hand, many advances in the field of human anæsthesia have resulted from experiments on the dog and other small domestic animals, and have been "rediscovered" by the veterinary profession many years later.

If the present position of veterinary anæsthesia is in any way to be regretted, this is in the main not due to any lack of inventive genius in the members of our profession, but rather to a lack of proper understanding of those agents and techniques which are already available. One hears much loose talk of "idiosyncrasy" to the anæsthetic drugs, and many anæsthetic deaths are attributed to such reactions. Most of these so-called "idiosyncrasies" have a simple explanation. How many cases of primary cardiac failure under chloroform could be prevented by a proper understanding of the mechanism underlying this phenomenon? How many cases of post-operative respiratory disease after inhalation anæsthesia could be prevented by routine premedication? How many deaths from asphyxia could be prevented by routine intubation?

It is in an attempt to answer such questions as these, and to provide a sound background to our knowledge of the anæsthetic agents and techniques which are used in the general anæsthesia of the dog, that the following notes have been collected. The agents and techniques used in human anæsthesia have been studied, and suggestions made for their use with the dog, except where obvious differences are known, The veterinary literature on this subject is scant, especially in this country, and little of importance has been published for many years.

The outstanding factor to be considered in veterinary anæsthesia is the complete lack of co-operation from our patients. As a result of this, I consider that any form of anæsthesia other than general anæsthesia has very little place in the veterinary field. Local anæsthesia has a limited application for minor

* This work was done whilst the author was holding a Research Training Scholarship from the Animal Health Trust.



William Thomas Green Morton, 1819-68.
(From *The British Medical Journal.*)

FIG. 1.

surgery in the docile animal, but I do not consider that the niceties of spinal anæsthesia, sub-arachnoid block, caudal anæsthesia, local nerve block, and refrigeration narcosis will ever occupy a great place in the anæsthesia of the dog.

To avoid psychic trauma in our naturally apprehensive patients the importance of a smooth induction cannot be overstressed, and to this end I consider that premedication could be practised to a far greater degree than it is at present. The provision of warmth, the maintenance of a proper fluid balance in the tissues, and the maintenance of a clear airway by intubation of the anæsthetised animal are all important factors which must be recognised by the modern practitioner.

The surgeon would be helpless without the aid of anæsthesia, but an anæsthetic improperly administered may render his task doubly difficult, or may indeed kill his patient before the operation has even commenced.

2. The Indications for General Anæsthesia

With the widespread advance amongst practitioners of the necessary knowledge and technical efficiency required for the administration of general anæsthesia to the dog, this procedure has now become commonplace for a great variety of purposes besides the relief of pain and the relaxation of the patient during major surgery.

Some of the more important of these other applications are as follows:—

1. To assist diagnostic examination; for the general examination of the fractious animal; for abdominal palpation in the apprehensive animal who maintains the abdominal wall in a state of tension; for bronchoscopy, œsophagoscopy, gastroscopy, etc.; for the diagnosis of trismus (temporal or masseter myoscitis) when the animal will not permit examination of the mouth.

2. To perform painful dressings; to remove sutures; to apply and to remove splints and plaster casts on the excitable animal; to facilitate manipulation at whelping when it is hoped to deliver the puppies via the normal route; to enable the breakdown of rectal impactions of bone, etc., to be performed per rectum.

3. To prevent movement; to prevent interference with wounds and inflamed lesions, especially post-operatively; to perform diagnostic radiography; to perform radiotherapy.

4. To relieve pain in any condition. The use of intravenous procaine should be considered in certain cases (Graubard and Ritter, 1947).

5. To prevent sneezing in cases of severe nasal hæmorrhage, to facilitate the arrest of such hæmorrhage.

6. To facilitate combing, grooming, clipping and trimming of badly matted coats of fractious animals.

7. For the relief of hysterical states. Many practitioners have resorted to prolonged deep anæsthesia for 24 to 48 hours for the relief of an animal which is exhibiting a continous hysterical state which will not respond to any other

treatment. In some cases this has resulted in considerable maintained improvement.

8. For the treatment of psychopathic conditions. It has been noticed that "bad tempered" dogs often show a considerable improvement in their demeanour following general anæsthesia for any purpose, and on these grounds the treatment of such dogs by prolonged general anæsthesia has been attempted with encouraging results.

9. Relaxant drugs have been used in the treatment of tetanus, strychnine poisoning, and chorea. The use of "Myanesin Elixir" has been suggested for the treatment of chorea in the dog.

10. For euthanasia. The majority of the methods used in general practice for the euthanasia of the small animals involve overdosage with one or another of the anæsthetic agents.

3. Physiological Considerations—respiration, circulation, anoxia

In order to maintain a smooth and successful anæsthesia, a familiarity with the physiology of the respiratory and circulatory systems is essential. Accordingly, it is intended to summarise very briefly a few of the more salient factors which are involved, and to indicate their practical importance.

The Respiratory System.

The function of the respiratory system is to provide at all times an adequate gaseous exchange between the air and the tissues. The shapes of the oxygen and the CO_2 dissociation curves for hæmoglobin permit such an exchange to take place under the most varied physical conditions.

The nervous mechanism responsible for the production of rhythmic inspiration and expiration is still a subject for controversy. The most widely accepted theory at the present time, however, is that of Pitts (1939 *et seq.*), according to which regular respiration depends upon the integrated activities of three mechanisms:—

(a) The Respiratory Centre (R.C.).
(b) The Hering-Breuer reflex.
(c) The Pneumotaxic Centre.

The R.C. consists of two parts, an Inspiratory Centre and an Expiratory Centre. Of these, the Inspiratory Centre would seem to be inherently dominant and to emit continuous inspiratory motor impulses to the respiratory muscles. However, as inspiration proceeds, stretch receptors in the lung tissue give rise to afferent impulses which travel via the vagus nerve to inhibit the Inspiratory Centre and stimulate the Expiratory Centre, so bringing about expiration. This is known as the "Hering-Breuer reflex."

Partridge (1935) has shown that under conditions associated with vascular engorgement and œdema of the lungs, this reflex is sensitised and respiration becomes more rapid and shallower as a result.

The Pneumotaxic Centre is a brain-stem mechanism which has a similar function to the Hering-Breuer reflex, viz., to interrupt the continuous impulses

from the Inspiratory Centre by inhibiting this centre and stimulating the Expiratory Centre. In normal respiration this mechanism is subsidiary to the Hering-Breuer reflex, but it is thought that under conditions which cause panting the Pneumotaxic Centre is so facilitated by impulses from the Thermoregulatory and other centres that it becomes the dominant factor in determining the respiratory rhythm.

The activity of the R.C. is influenced by afferent stimuli from a variety of sources. It receives voluntary impulses from the cerebral cortex. It receives impulses from many peripheral receptors, including those in the carotid body and the aortic arch. These receptors may be sensitive either to changes in the blood chemistry (oxygen lack, and to a less extent CO_2 accumulation) or to changes in the blood pressure. Furthermore, the neurones of the R.C. itself are sensitive to their chemical environment, but these are more sensitive to CO_2 accumulation than to oxygen lack. These factors combine to modify respiration, and to a less extent also circulation, accordingly.

It should be remembered, however, that the theory of respiration outlined above, in which an aperiodic respiratory centre is modified by interruptor stimuli from the Hering-Breuer reflex and the Pneumotaxic Centre, is open to doubt. It has been challenged by Bernthal (1944), Borison (1948), and more recently by Hoff and Breckenridge (1949), who have produced experimental evidence which suggests that the medullary Respiratory Centre of the dog is itself inherently periodic.

All the anæsthetic agents in common use in veterinary practice to-day, with the exception of ether, act as respiratory depressants by depressing the sensitivity of the R.C. and the peripheral receptors to the various afferent stimuli. Sensitivity to oxygen lack in the carotid body and aortic arch receptors appears to remain after sensitivity to CO_2 accumulation in the R.C. itself has been lost. In deep, e.g., barbiturate, anæsthesia one may see the deep sighing movements characteristic of respiration maintained by the effect of anoxia alone.

During an operation, afferent impulses from somatic areas and the parietal peritoneum act as stimulants to respiration, but impulses from certain areas of the visceral peritoneum bring about a temporary inhibition of respiration in inspiration. At the conclusion of an operation all external and somatic stimuli to respiration cease and, as would be expected, respiration at this stage normally becomes markedly depressed.

Reflex inhibition of respiration occurs immediately before vomition, whilst intubation is being performed, and temporarily when obstruction occurs in the breathing system.

The Circulatory System.

The circulatory system functions in such a manner that it is complementary to the respiratory system. A deficiency of function in either of these systems is normally compensated to a degree by an increase in the activity of the other.

Far less, however, is known concerning the central nervous mechanism

which controls the circulatory system. The most widely accepted theory at the present time is that there are, in the medulla, two closely associated areas which represent a Vasopressor (Vasomotor or Vasoconstrictor) Centre and a Depressor Centre.

The Vasopressor Centre sends sympathetic fibres to the heart, and stimulation of these fibres results in an accelerated and more vigorous heart beat. This centre also sends sympathetic fibres to the arterioles via the various spinal vasopressor centres, so that vasopressor action on the heart is accompanied in the normal animal by vasocontriction of the arterioles.

The Depressor Centre sends parasympathetic fibres to the heart via the vagus nerve, and stimulation of these fibres results in a slower heart rate. It is thought that depressor reflexes are constantly active and that efferent vagal impulses constantly maintain the heart in a state of "vagal tone." Furthermore, Hoff (1947) has stated that: ". . . . almost all of the increase in heart rate which takes place with exercise in the dog . . . . may be ascribed to a central inhibition of vagal tone . . . ." (as opposed to increased sympathetic stimulation).

It is probable that the Depressor Centre has very little vasodilator action on the arterioles, but some vasodilator fibres emanate in both the sympathetic and the parasympathetic systems.

Like the Respiratory Centre, the Vasopressor and Depressor Centres receive afferent stimuli from a variety of sources:—

1. The most clear-cut reflexes are those which follow stimulation of the receptors in the carotid body and the aortic arch by an increase in the arterial pressure or by changes in the chemistry of the blood (see above). It is thought that these reflexes are to some degree always active, but that, e.g., an increase in the arterial pressure causes a more frequent discharge of afferent impulses to the medullary centres, which in turn further stimulate the parasympathetic fibres in the vagus. Thus vagal tone is increased and the heart slows.

Other afferent fibres are variously distributed amongst the blood vessels themselves.

2. The respiratory tract is an important area for the receipt of stimuli which are transmitted to the Vasopressor and Depressor Centres. The nasal mucosa is most receptive in this respect, but lower zones are also capable of acting as receptor areas. This reflex is seen, e.g., on the introduction of an irritant vapour into an anæsthetic mixture.

3. The gastro-intestinal tract—stimulation of the gall bladder especially, by mechanical pressure or distension, gives rise to the depressor reflex.

4. There seems little doubt that the Vasopressor and Depressor Centres are linked with the higher brain centres, with the Respiratory and other medullary centres, and that they also receive impulses from the majority of general somatic and visceral afferent nerve fibres.

Morphine and chloroform increase the sensitivity of these reflex mechanisms, and the barbiturates depress them.

Under general anæsthesia the muscle tone, which normally assists in the maintenance of the systemic blood pressure, is no longer present. Furthermore, the anæsthetic agents themselvs may weaken the force of the heart beats anything from 5 per cent (ether) to 40 per cent (chloroform). The resultant fall in blood pressure can, of course, be largely corrected in the normal animal by the proper and timely use of an appropriate pressor drug. But when there is general venous congestion accompanied by myocardial weakness, then no amount of pressor drug action will restore tone to the flaccid venous system.

It has been known for a long time that there is enlargement of the spleen under barbiturate anæsthesia (and in the human in many cases of spinal anæsthesia). Hahn, *et al.* (1943), have shown that spleens removed from dogs under pentobarbital anæsthesia are on an average four times the weight of those removed under ether anæsthesia. They also demonstrated that up to 30 per cent of the previously circulating red blood cells may be present in the enlarged spleen. These cells may be largely restored to the circulation by the intravenous administration of epinephrine.

The problem of primary cardiac failure will be discussed in Section 8.

Anoxia.

The most serious anæsthetic hazard is anoxia. This condition may arise in several ways, and accordingly may be designated:—

1. Anoxic anoxia, in which there is a deficient supply of oxygen to the lungs.

2. Stagnation anoxia, in which there is circulatory failure.

3. Histotoxic anoxia, in which a number of factors contribute to bring about a condition of "shock."

4. Anæmic anoxia, in which there is a deficiency of circulating hæmoglobin.

When anoxia occurs, the various chemo-receptors discharge afferent impulses at an increasing rate to the Respiratory and Vasopressor centres as an immediate response. The bone marrow increases its activity as a long-term response. These are the only two tissues which respond to anoxia by an increase in their activity.

The first signs of anoxia are an increase in the pulse rate, and then a gradual fall in the venous pressure. The treatment of this condition will depend on the nature of the causal factors.

4. Factors which affect the Dosage of the Anæsthetic Drugs

The computation of an accurate dose is not often imperative in clinical anæsthesia since both the inhalation anæsthetics and the short-acting barbiturates should be administered until the required degree of anæsthesia has been produced. It is an advantage, however, to be able to anticipate the reaction of an animal to a given dose of an anæsthetic agent, apart from which it will be necessary occasionally to give pentobarbitone ("Nembutal") by mouth or by intraperitoneal injection, and the dosage of drugs for premedication has always to be computed.

Thus it is well to consider those factors which render an animal more or less susceptible than normal to the anæsthetic agents, for with a proper understanding of these factors we can explain much of what would previously have been placed under the heading of " Idiosyncrasy."

The dose of an anæsthetic agent will be calculated in the first place upon the weight of the animal in accordance with a standard dose per unit weight. However, it is well known that there are frequently marked variations from the normal response to such a standard dose, and such variations result mainly from corresponding changes in the metabolic rate (M.R.) of the animal.

The factors which may affect the M.R. of an animal to be submitted to general anæsthesia are as follows:—

1. The Relative Size of the animal. The basal metabolic rate (B.M.R.) per unit of body weight of small animals is greater than the B.M.R. per unit of body weight of large animals (Fig. 2). Thus the toy dog requires a larger dose per pound of body weight than the larger breed.

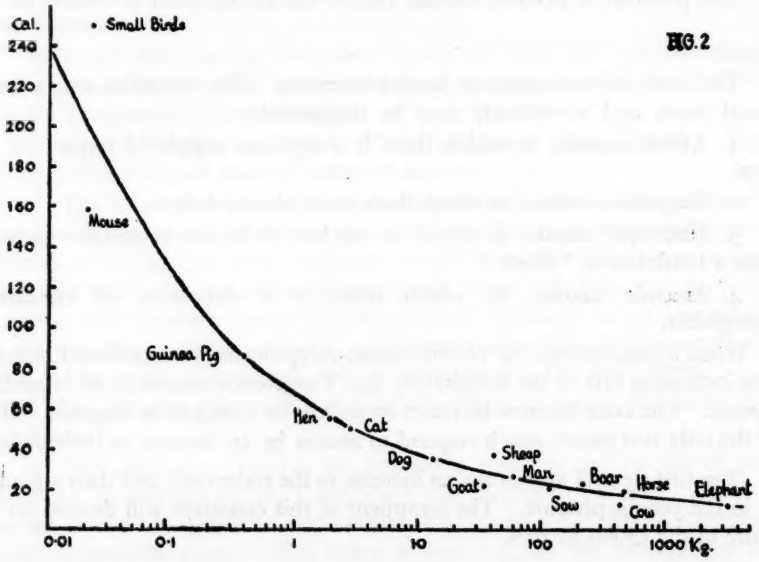


FIG. 2.—The relationship between the average basal metabolic rate per Kgm. per day of different species (y-axis) and the average body weight (x-axis). Semi-logarithmic chart. Modified from Benedict: "Vital Energetics: A Study in Comparative Basal Metabolism." Carnegie Institution of Washington Publication No. 503, 1938. (Dukes: 1947.)

2. The Condition of the animal. The animal with large quantities of inactive, non-metabolising tissue, such as fat, will have a lower B.M.R. per unit of body weight than the lean, muscular animal, and will require a correspondingly smaller dose. Thus the obese spaniel of 50 pounds weight will

require considerably less of the anæsthetic agent than the muscular greyhound of the same weight.

3. The Age of the animal. The B.M.R. is low in the newborn, highest at the time of puberty and early adulthood, and gradually declining towards old age (Fig. 3).

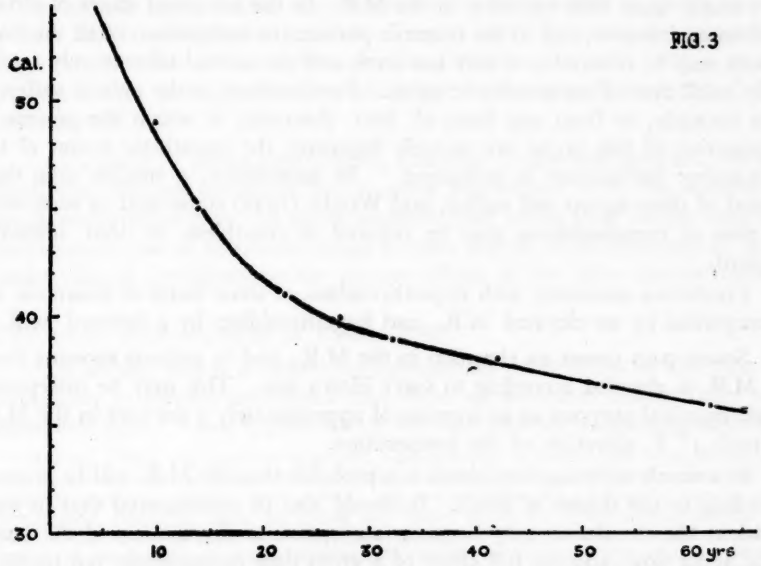


FIG. 3.—The relationship between the age of the human male (x-axis) and his basal metabolic rate in calories per square meter per hour (y-axis). Constructed from the DuBois Normal Standards as modified by Boothby and Sandiford. Fulton: 1947.)

4. The Sex of the animal. The B.M.R. of a female animal is approximately 7 per cent less than that of a male. During pregnancy, however, a rise occurs, due to the metabolic activity of the fœtuses. It would appear, also, that sex may have other effects on the response of an animal to a given dose of an anæsthetic agent than those resulting from the difference in M.R. (see below).

5. Recent Feeding. A large meal of meat may increase the M.R. of dogs as much as 90 per cent above the basal level (Dukes, 1947). Lusk (1928) has shown that the maximum effect of a meal of fat is not manifest until the sixth hour after ingestion. In general, in carnivorous animals, the B.M.R. is not regained until 12 and 18 hours after the last meal.

6. Recent Work. Muscular activity increases the M.R. Thus a greyhound coming off a track with an injury would require a relatively large dose of an anæsthetic agent for some hours afterwards.

7. Premedication. Morphine lowers the M.R., and Anderson (1929) and others have reported a lowering of the oxygen consumption by up to 30 per cent following the use of this drug in man. Atropine administered alone will cause a

slight rise of the M.R. When these two drugs are administered together in normal dosage, however, the M.R. is lowered.

8. Fear and Excitement. The M.R. is raised in the frightened, apprehensive and struggling patient.

9. Concurrent Disease. The majority of pathological conditions in their early stages cause little variation in the M.R. In the advanced stages of almost all diseases, however, and in the toxæmic patient, the metabolism of all the body systems may be reduced to a very low level, and the animal tolerate only a relatively small dose of an anæsthetic agent. Furthermore, in the animal suffering from toxæmia, or from any form of liver dyscrasia, in which the powers of detoxication of this organ are severely impaired, the anæsthetic action of the short-acting barbiturates is prolonged. In accordance, a smaller dose than normal of these agents will suffice, and Wright (1942) states that in such cases the dose of pentobarbitone may be reduced to two-thirds of that normally required.

Conditions associated with hyperthyroidism or some forms of leukæmia are accompanied by an elevated M.R., and hypothyroidism by a lowered M.R.

Severe pain causes an elevation in the M.R., and in patients showing fever the M.R. is elevated according to van't Hoff's law. This may be interpreted for all practical purposes as an increase of approximately 7 per cent in the M.R. for each 1° F. elevation of the temperature.

In animals suffering from shock it is probable that the M.R. will be lowered according to the degree of shock. It should also be remembered that in such a patient the circulation may be poor, absorption or distribution of the anæsthetic agent slow, and the full effect of a given dose consequently not manifest for a longer time than usual.

There are also other factors which may affect the response of an animal to a given dose of an anæsthetic agent, apart from those which bring about changes in the M.R., and under this heading will be considered the other possible effect of sex, as mentioned above (4), also the concurrent administration of drugs other than premedicant or anæsthetic drugs, and the effect of concentration and rate of administration of the anæsthetic agent.

Sex.

It was shown by Nicholas and Barron (1932) that there was a definite sex variance in the susceptibilty of rats to anæsthesia with sodium amytal. Male rats were least susceptible, requiring an average dose of 20 mgms./100 gms. Non-pregnant females were more susceptible, and pregnant females most susceptible, requiring an average dose of only 10 mgms./100 gms. On the other hand, Kennedy (1934) could find no sex variance in the susceptibility of mice to anæsthesia with evipan.

Also of interest in this connection are the experiments of Selye (1941), which showed that steroid hormones injected by the intravenous or intramuscular routes in massive doses are capable of bringing about general anæsthesia in various experimental animals. Only those steroids which have a hormonal action will produce anæsthesia. Females are more susceptible to anæsthesia by this means than males. The spaying of females does not alter their susceptibility, but the castration of males increases their susceptibility to that of the females. The prolonged subcutaneous injection of androgens lessens the susceptibility of females and castrated males down to that of the intact males. This anæsthetic action of the steroids is in all cases enhanced by partial hepatectomy.

It would thus seem probable that the dominating steroid hormone in the animal body has some influence on the susceptibility of that animal to anæsthetic agents. This effect can best be understood by imagining the female animal, and the castrated male, as being fully susceptible and requiring the smaller dose, whereas the presence in the body of androgens, as in the androgen-treated female or the normal male, confers some resistance to the anæsthetic agents upon the animal which consequently requires a larger dose. It would be interesting to know whether the reverse holds true, viz., whether the male who is receiving treatment with œstrogens is more susceptible to the anæsthetic agents than the normal male.

As a result of recent experiments, Cameron (1949) has proposed the hypothesis that the sex hormones are in some way linked with the detoxication mechanisms of the liver. It seems probable that whilst these factors may affect the required dose of anæsthetic drugs to some degree, their effect will be masked under clinical conditions by the greater effects of the other factors described.

Concurrent Administration of Other Drugs.

An animal which is under the influence of other drugs at the time of its submission to general anæsthesia may have an enhanced susceptibility to the anæsthetic agent. This is particularly the case with the sulphonamide drugs.

Adriani (1939) reported an increased susceptibility to barbiturate anæsthesia in rats after treatment with sulphanilamide, but no effect in the case of each of a series of other anæsthetic agents. Butler, *et al.* (1941), did not consider his (Adriani's) results of any significance, especially since no effect was found when the blood sulphanilamide levels were of the order of those used in clinical practice. These authors confirmed Adriani's results to an extent on mice, however, in which animal they reported an increased susceptibility to anæsthesia with pentobarbitone, ether, and chloroform after sulphanilamide treatment. They conclude with the opinion that this effect is sufficient to be reckoned with when one large predetermined dose of an anæsthetic agent is being administered.

Concentration, or Rate of Administration, of the Anæsthetic Agent.

Various opinions have from time to time been expressed as to the effect of the rate of administration, particularly of the short-acting barbiturates, on the dose required and on the rate of detoxication within the body. Muir (1947) quotes Knight as suggesting that the slower the injection of a given dose of a barbiturate drug, the less was the effect of that dose.

5. Premedication and Basal Narcosis

By premedication is meant the treatment of an animal prior to anæsthesia with a view to:—

(i) Decreasing the mucous secretion of the respiratory tract;

(ii) Reducing the metabolic rate;

(iii) Allaying the natural apprehension of the patient.

Drugs for premedication are normally administered by subcutaneous injection, but in the event of an emergency may be given by the intravenous route.

Premedication could with advantage be practised to a far greater extent in canine anæsthesia than it is at present.

By basal narcosis is meant the induction of a basal state of narcosis or hypnosis on which to superimpose the anæsthetic state. Basal narcosis probably has little application in canine anæsthesia.

Drugs for Premedication.

ATROPINE.

The only useful action of atropine is a marked depression of the mucous secretion of the respiratory tract. This is desirable to combat the otherwise excessive secretion which is produced by the irritant vapour of ether, and by the relaxant curare. But the depression of secretion is so marked that if atropine is given to an animal, and not followed by the use of either ether or curare, then there is a danger that the secretion will become so viscid as to cause pulmonary complications; these may be more serious than can result from the use of ether alone without the use of atropine.

Atropine causes slight excitement and a rise in the M.R., hence it is normally administered in conjunction with another drug which has a depressant action, e.g., morphine. Young animals will tolerate doses of atropine which would seem excessive when compared with the adult dose.

(To be concluded)

THE PERSISTENCE OF DDT CRYSTALS IN THE COATS OF SPRAYED CATTLE, WITH SPECIAL RELATION TO TSETSE CONTROL

By P. BRACEY, M.Sc.,

Colonial Insecticides Committee.

A SMALL field trial on cattle was carried out with an oil-bound suspension of DDT crystals (TP 724) made by the Shell Petroleum Company, to determine whether this form of DDT would be more successful as a cattle spray than emulsions or solutions in controlling flies attacking cattle. Previous experience has shown that the deposit left from DDT emulsions on sprayed cattle or on the short-haired facial regions of sprayed or dipped sheep has a very short period of effectiveness. This was due to the rapid loss of the DDT deposit from the hair by rubbing, absorption and washing off by rain. The oil-bound suspension tested, containing about 50 per cent DDT, possessed very good properties of adhesion to plane surfaces of various types. The crystals ranged in size up to 60 microns diameter, with a stated mean of about 35 microns.

In preliminary tests two Ayrshire calves and later five cows were used. On the two Ayrshire calves the necks only were sprayed over an area of about 1 sq. ft. on each side, extending from the shoulder to the angle of the jaw. The left side of the neck was sprayed with 2.5 per cent DDT, and the right side with 5.0 per cent DDT. A Four Oaks hand sprayer was used and the sucking tube in the reservoir was inserted through a cork into a 3 × 1 in. glass tube containing the measured amount of insecticide. The left neck of each animal was sprayed with 20 c.c. of 2.5 per cent DDT, and the right neck with 10 c.c. of 5 per cent DDT. This gave a theoretical coverage of 500 mgm./sq. ft. of DDT over the plane surface. Run-off was nil and loss from other causes was negligible as the nozzle was held close to the hide.

Hair clippings were taken (from the back as control) on progressive dates and placed in gauze cages 6 in. high and 3 in. in diameter with tsetse flies, in a constant temperature and humidity room maintained at 25° C. and 70 per cent R.H., and left overnight. Tsetse pupæ *Glossina palpalis* imported from Uganda were used to provide flies for the tests. *Glossina palpalis* is extremely sensitive to DDT, therefore any trace of DDT on the hair would be likely to kill the flies. The results of this test are tabulated below:—

TABLE I

	Age of deposit in days	Per cent DDT concentration	Average per cent kill	No. flies used
	2	2.5	96	51
	2	5.0	86	42
Control	2	—	10	30
	11	2.5	0	20
	11	5.0	4	25
Control	11	—	0	20

These tests showed conclusively that all effective DDT deposit had been lost from the necks only 11 days after treatment. The use of the neck region is admittedly a severe test, as the hair is subjected to almost continuous shearing and cleaning action by the wrinkling of the skin.

A second test was carried out using five fresh and fully-grown cattle. The two calves of the previous test were used as controls.

Each cow had a surface area of roughly 30 sq. ft., and was sprayed all over with 6 pints of 2.5 per cent DDT suspension, using a pneumatic knapsack sprayer at about 20 lb./sq. in. This volume of spray ensured that each animal was soaked, and although the 2,000 mgm./sq. ft. used was not all retained in the hair, the dosage was certainly much higher than would normally be recommended.

The cows (four Ayrshires and one Shorthorn) were sprayed in their stalls and then turned out to pasture. The normal routine of milking and general husbandry was not altered. The control calves were kept in a separate field and building.

Hair clippings were taken at intervals from the sides and back of each cow, with the results tabulated below:—

TABLE II

	Animal No.		Deposit age/days	Hair site	No. flies killed	No. flies used
1	Ayrshire	...	5	Back and Belly	22	23
2	"	...	5	"	17	17
3	"	...	5	"	23	23
4	"	...	5	"	20	20
5	Shorthorn	...	5	"	15	15
6	Ayrshire	...	Control	"	2	19
7	"	...	Control	"	1	24
1	Ayrshire	...	7	Back and Belly	17	17
2	"	...	7	"	19	19
3	"	...	7	"	17	17
4	"	...	7	"	25	25
5	Shorthorn	...	7	"	18	18
6	Ayrshire	...	Control	"	0	26
7	"	...	Control	"	0	21
1	Ayrshire	...	13	Belly	0	20
2	"	...	13	"	0	20
3	"	...	13	"	0	20
4	"	...	13	"	0	20
5	Shorthorn	...	13	"	10	20
6/7	Ayrshires	...	Control	"	0	40
1	Ayrshire	...	18	Back	20	21
2	"	...	18	"	5	20
3	"	...	18	"	13	26
4	"	...	18	"	5	30
5	Shorthorn	...	18	"	26	26
6/7	Ayrshires	...	Control	"	3	40

The results show a similar picture to that in the preliminary trial. *Glossina* has a preference for feeding on the belly of cattle, so that it is not likely from the results of these tests that cattle spraying would be likely to yield a satisfactory reduction of tsetse populations.

The inclusion of the one Shorthorn cow was quite by chance, but the results on this one animal were of some interest. It was only hair from this Shorthorn which gave any kill 13 days after spraying, with hair taken from the belly region.

The Shorthorn differs markedly from the Ayrshire cow in the texture and characteristics of its coat. In the Shorthorn the hair is rougher, stands out more from the skin and is generally longer, being about 2 in. in length and very much thicker. The coat of the Ayrshire is fine and silky, and lies flat on the skin. The thicker and hairier the coat, the more likely is it that a greater load of DDT will be retained, as in dipped sheep. A heavily fleeced sheep retains enough DDT to kill alighting *Lucilia* up to 6 weeks after dipping. On this evidence it might be worth while considering tests with cattle having much heavier and thicker coats—the Galloway, for example—although it is not known whether there is any likelihood of such thick-coated animals being suitable for tropical climates.

REVIEWS

FROM THE GROUND UP, an outline of real economy, by Jorian Jenks, with an introduction by H. J. Massingham. London: Hollis & Carter. Price 12s. 6d.

MR. JORIAN JENKS has written a book which, no matter how much one may disagree with him, is stimulating to read. He believes that society as we know it to-day will have to be regenerated "from the ground up." The further man is divorced from the soil, the greater becomes the imbalance of society. Men were not meant to live in large cities, but in small communities. Large cities, and, indeed, urbanisation of any kind, disintegrate man. He becomes an isolated unit, a cog in a machine, a performer of certain actions which mean nothing to him. In the village, and especially the village of the more immediate past, each worker was a craftsman and an integral part of the village life. Ready-made doors did not come from Sweden, any more than leather from America. The farmhand, the smith, the carpenter, the mason, each calling required by the community, lived within the community, and those who practised these callings were an obvious part of the life of the community, with the result that quality of service as well as quality of the product were a first desideratum, and as a result men took pride in their work, and saw to it that their workmanship merited that pride. To-day, quality as a desideratum has disappeared and has been replaced by quantity obtained by any means that man's ingenuity can devise.

The industrialisation of agriculture, the monetary burdens of our economic system, our export-import policies, and many like matters are reviewed in this book and condemned, and it would appear that the author would have us, as a nation, withdraw from the world and return to the position we once held, when we concerned ourselves with, and concentrated on, feeding ourselves and supplying our own needs, which, he contends, we are well able to do. This seems to be an unattainable Utopia (even if a desirable one, which many will take leave to doubt), as also is the urgent plea put forward for a return to mixed farming. There is but little doubt that the world will be driven to revise and restate its values, if civilisation as we know it is to continue, and the reading of this book will compel anyone who has given no thought to the matter to envisage the problems which lie before this country and the whole of the Western world. We agree with Mr. H. J. Massingham, who contributes a laudatory foreword, that in writing this book Mr. Jenks has performed a timely and useful service. He may have overstated his case in some respects, but he has put the position clearly, so that all who run may read.

PRACTICAL FARRIERY. London: Sir Isaac Pitman & Sons, Ltd., Price 8s. 6d.

THIS is a useful little book which will be welcomed by farriers who wish to enhance their skill and knowledge. Within its relatively short compass it deals intelligently and simply with the theoretical and practical problems of the trade. Its simplicity is probably its greatest asset, and we have no doubt that

it will be read with better understanding by the average student or journeyman than are some of the more elaborate tomes. The information in Chapter VII, i.e., on "Hints and Tips to Young Farriers," has probably never been excelled.

The author has been at pains not to transgress the legitimate bounds of a farrier's work.

The format, illustrations and exposition are good, and the book is of a convenient size for ready reference.

We are sure that farriers, and especially those who are in the training period, will find it to be almost a miniature vade-mecum.

NEWS

THE ANIMAL HEALTH TRUST

Dr. Francis C. Minett, C.I.E., M.B.E., D.Sc., M.R.C.V.S., has been appointed Director of the Trust's group of Farm Livestock Research Stations at Houghton Grange, Huntingdonshire.

The following awards of Research Fellowships and Research Training Scholarships have been made:—

Wellcome Veterinary Fellowship to Mr. Peter Storie Pugh, M.B.E., M.C., T.D., M.A., M.R.C.V.S., A.R.I.C., son of L. P. Pugh, Esq., B.Sc., F.R.C.V.S.

I.C.I. Fellowship to Mr. Barry Albert Cross, B.A., B.Sc., M.R.C.V.S.

Cooper Fellowship to Mr. Keith Macfarlane Dyce, B.Sc., M.R.C.V.S.

Research Training Scholarships have been awarded to: Mr. T. A. Douglas, M.R.C.V.S., Mr. L. W. Hall, M.R.C.V.S., Mr. J. G. Phillips, M.R.C.V.S., Mr. A. J. Stevens, B.Sc., M.R.C.V.S., and Mr. W. J. Brinley Morgan, B.V.Sc., M.R.C.V.S.

A SOUVENIR

For the N.V.M.A. Congress, Burroughs Wellcome & Co. have prepared a special folder, copies of which are available to the profession. The outer cover illustrates the famous legend of Gelert, the Welsh hound. Inside are descriptions of places of interest within reach of Cardiff. An interesting and useful souvenir.

Publishers' Notices

The British Veterinary Journal, with which is incorporated The Veterinary Journal, is published monthly, and copy for advertisements should be in the hands of the publishers—Baillière, Tindall and Cox—not later than the 20th of the preceding month, if proof is required. Tel.: Temple Bar 3386.

Letters for the Journal, literary contributions, reports, notices, books for review, exchanges, new instruments or materials, and all matter for publication (except advertisements) should be addressed to the Editor.

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